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POWER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

ISSUED WEEKLY

VOLUME XLIX

153239
12/11/19.

January 1 to June 30, 1919

McGRAW-HILL COMPANY, Inc.
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POWER

GENERAL INDEX TO VOLUME XLIX

January 1 to June 30, 1919

EXPLANATORY NOTE

Illustrated articles are marked with an asterisk (*), book notices with a dagger (†), inquiries with a double dagger (‡). The cross-references condense the material and assist the reader, but are not to be regarded as complete or conclusive. So, if there were a reference from "Boiler" to "Piping," and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross-reference. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

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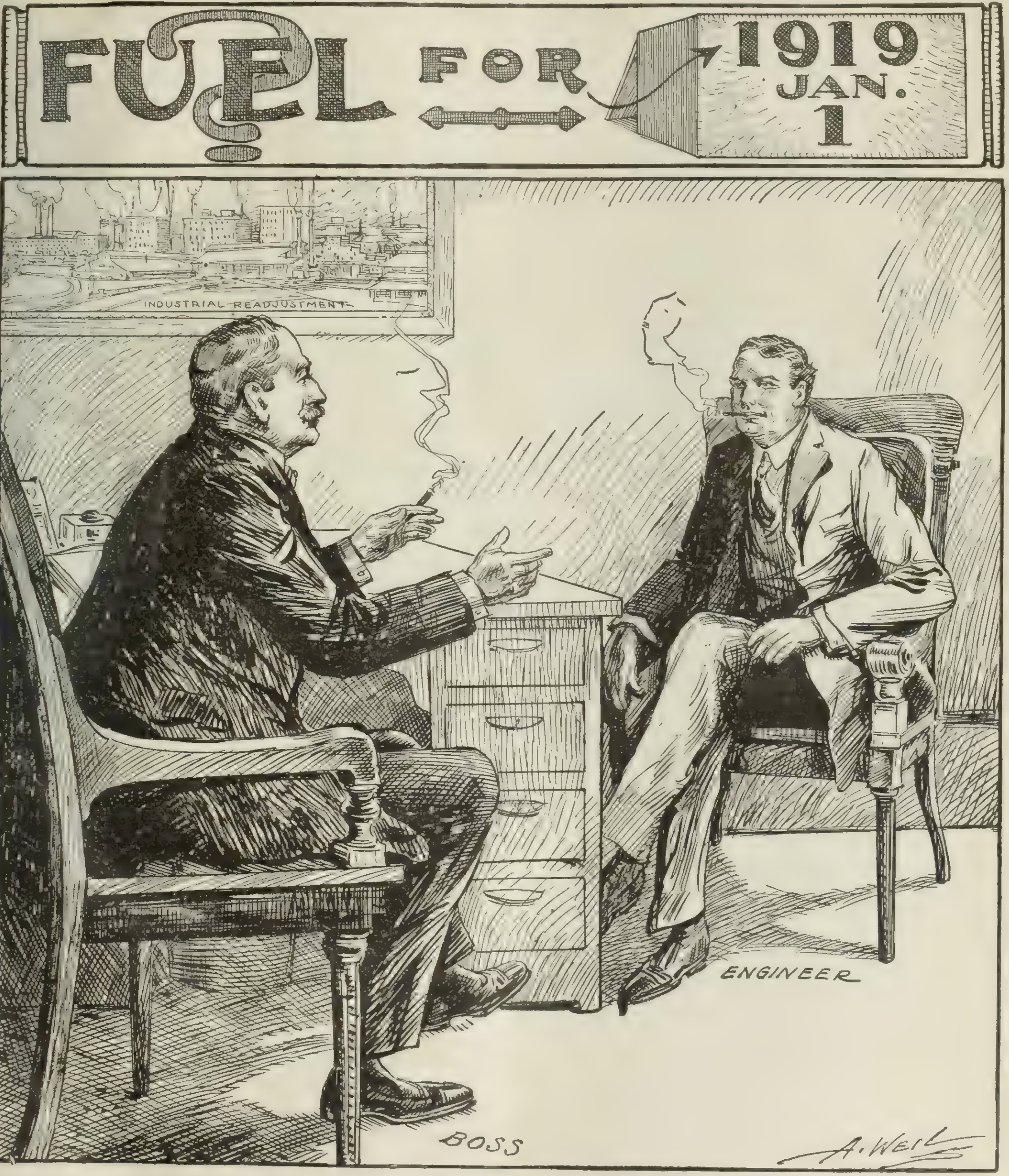


For the power plant this era of reconstruction is a period for reform. War times have revealed the economies that can be realized by stopping leaks and by better practice in the boiler room.

Review of the Year in the Power Field

WITH war work absorbing 90 per cent. of the energy of the mechanical industry and with the remaining 10 per cent. devoted to necessities, there has been no opportunity for pioneer work in the power-plant field, even if scarcity of materials, shortage of labor, excessive costs and overloaded transportation facilities had not prohibited effort in this direction. As a matter of fact experimental, inventive and development work has been practically suspended for the last two years, so that except for isolated cases where necessity has been there is little progress to report.

FUEL CONSERVATION EFFORTS

There have been developments, however, originating as necessities imposed by the war, that are noteworthy and will leave their impression on the field.

Of primary importance are the fuel-conservation efforts made by the Government and the means employed to effect savings in the consumption of coal and oil. The power-plant questionnaire has brought results. An estimated saving of 3,500,000 tons is reported for the first six months. This is at the rate of 7,000,000 tons per year, and is only a beginning. In the plants that adopted the standard recommendations and kept systematic records there have been savings as high as 25 per cent. and the average is placed between 10 and 15 per cent. From statistics gathered from widely separated districts the "daylight" saving is estimated at 1,250,000 tons, the skip-stop plan is reported to have saved about the same amount, and the direct result of the entire industrial conservation program has been given an annual saving throughout the country of 25,000,000 tons of coal, without reducing the output of the factories. In some of the states work was slow in starting and there was some lapse of time before activities began in the individual plants. It is safe to say that the actual saving was only a small part of what it might have been if the work under the present organization had been continued for another year.

OWNERS AWAKENED TO POSSIBILITIES OF EFFICIENT OPERATION

While under the strenuous war conditions existing for the greater part of the year even the relatively small saving made was gratifying, it is only an incident to the benefits that may be expected for the future. The mere fact that the power-plant owner has been awakened to the possibilities of efficient operation, that the engineer generally has been aroused from former routine performance and may expect coöperation from above, means much more than a temporary saving. The work done by the Government will continue to bear fruit in the years to come. Without considering the question of conservation, the owner, from the standpoint of personal gain, will not permit resumption of wasteful methods in the power plant. As for the engineer, his reputation is at stake. Normally conscientious, he will appreciate the coöperation that he has always solicited, and with the equipment and instruments necessary for economy, the progressive engineer will maintain and perhaps better the record set in the present emergency. The war has made evident the real meaning of efficiency, and not only in power-plant work but in all processes of production, manufacturing and distribution, it is to be the keynote in the reconstruction period now upon us.

Since the signing of the armistice there has been a decided slowing up in the activities of the United States Fuel Administration. Report has it that the work of the conservation department ends with the year, although regulation of distribution, particularly of domestic coal, will continue throughout the winter. The statistical division of the organization will hereafter be under the direction of the United States Geological Survey, and it is hoped that the work of conservation will be continued by the Bureau of Mines. As this procedure is in accord with the general trend of opinion in the field, it will meet with approval, particularly as it was feared momentarily that the information accumulated at so much expense in time and money would be lost. Although a new organization will have to be perfected, the work is in good hands and with proper Government support should be given the efficient attention for which the Bureau is noted.

POOLING OF POWER

As a part of the plan of conservation considerable attention was given to the consolidation of the services of adjacent plants where an economy might be effected by the more efficient plant supplying its less economical neighbor. Owing to the limited time available and to the fact that compulsion was not resorted to little was accomplished along this line. In the East and the far West because of the excessive demands for power and the need for reserve capacity, interconnection between large electrical systems was common. In the Southeast and the Central West it already existed.

COÖPERATION BETWEEN PRIVATE PLANT AND CENTRAL STATION

With the ostensible purpose of saving coal an active campaign to take over noncondensing isolated plants for the duration of the war was conducted generally by the central station. The movement was facilitated by the high price of fuel and the scarcity of competent firemen. A comparison was made between the three pounds of coal required by the central station to produce a kilowatt-hour at the switchboard and the six to ten pounds utilized in the noncondensing private plant. Evidently a large saving in coal was possible, but only on the basis of the electrical load. When combined with heating and other steam-using services, the question became more complicated and investigation developed that in the majority of cases there would be a loss instead of a gain by separating the services. In most plants, however, this argument does not apply to the nonheating period of the year. When no exhaust steam is required for heating or other purposes and there is no steam-using equipment other than the generating units, there is a decided advantage in purchasing summer current when it can be obtained at a reasonable rate. Summer load is also advantageous to the central station in utilizing equipment installed to carry the heavier winter load.

Continuous effort has been made to fill the summer valley, and some of the more progressive public utilities have begun to realize that this desirable condition might be attained by coöperation with the isolated plant. Discarding the old-time policy of "all or none" and concentrating their efforts on a plan that would be of mutual advantage has resulted in progress. In Chicago certain plants have adopted the foregoing plan with profit, although in others investigation revealed that no saving could be made. It is of course a question for individual analysis.

MORE COAL STORED THAN EVER BEFORE

Relative to the coal situation one of the difficulties was a shortage of labor in the mines. When war was declared two years ago, there were 700,000 miners. About 60,000 were lost in the draft and many more to other industries paying higher wages. Notwithstanding this loss in labor, there was a 10 per cent. increase in production the first year, and from statistics available at the time of writing a similar gain was made last year. A production of 700,000,000 tons of coal was anticipated and the actual output closely approximated this figure. To spread out the work of the miner and make it continuous the year around, there was a great call for storage. Coal users responded and it is safe to say that more coal was stored last year than ever before. With the so-called Western coals from Illinois, Indiana and other states, considerable trouble was experienced from fires, due largely to lack of knowledge of what to avoid, although literature giving explicit instructions had been widely distributed. It is gratifying to note that arrangements were made by the Fuel Administration to visit as many of these fires as possible to ascertain the cause and put them on record on photographic plates. These illustrations and the accompanying data are to be published at an early date, giving a wealth of valuable information for future guidance.

RELIEVING RAILWAY CONGESTION

Another angle of the coal problem was the lack of transportation facilities. One suggestion to relieve the situation was the installation of pipe lines from the mines to the centers of distribution. The coal was to be pulverized and washed at the mines, mixed with water and pumped to its destination at an estimated cost ranging from twenty-five cents to one dollar per ton in extreme cases.

Generating current at the mines and distributing it by high-tension lines to points where electrical energy is required was a plan given impetus by the exigencies brought about by the war. Although in favorable localities a number of such plants already exist, it was proposed to divide the country into districts, each section to be served by large central stations at the sources of fuel supply.

In either plan there are certain advantages, but the initial investments would have been enormous and the time element involved would not have permitted the immediate relief required. The zone system for the distribution of bituminous coal was the final solution. It succeeded in relieving congestion by reducing the car mileage per ton of coal delivered. The facilities available were thus utilized to better advantage, and the railways were able to handle more coal. Temporarily, the plan did embarrass coal users where a change in fuel was enforced and the equipment at hand had not been designed properly to meet the new conditions. Modifications in the furnace and in the methods of operation were necessary, but when the proper adjustments had been made, the consumer had learned to burn an inferior coal and quite frequently at a reduction in the cost of operation.

PHYSICAL PROGRESS HALTED BY THE WAR

As to developments much that was said in the review of a year ago still applies. There has been a brief halt in the remarkable progress made in the last few years. During the short period of readjustment the engineer will transfer his work from war to peace. Taking advantage of the lessons of the past and the many new things learned under the stress of the world conflagration, coupled with the new spirit born of the war, demanding efficiency and coöperation, the opportunity for progress is boundless. If precedent is an indication, the advance in the next few years should eclipse all records of the past.

NOTABLE STEAM POWER PLANTS

Although in the year just past the tendency has been toward makeshifts to get along with the equipment installed, due to Government priorities, long deliveries and excessive cost, and at the same time carry an increased load, a number of noteworthy plants have been placed in service. Some stations of enormous proportions have been built to serve munition works, but of these details are not available. At Windsor, W. Va., work has been continuing on a huge mouth-of-mine plant designed to deliver bulk energy to the surrounding industrial district. A capacity of 200,000 kw. in six units is planned. Of this two 30,000-kw. machines are in service, two more were expected to be ready before the close of the year and the final installation to be completed shortly after. A turbine is served by four cross-drum boilers, each having 12,625 sq.ft. of heating surface and equipped with a superheater, an individual economizer, induced draft and forced draft applied to an underfeed stoker. The operating pressure is 250 lb. and the superheat 250 deg., giving a steam temperature approximating 650 deg. Coal direct from the mine is received in a pit under a central firing aisle and is delivered to individual stoker hoppers of large capacity. Between each pair of turbines is a condenser pit 74 ft. deep, containing two horizontal condensers of the Leblanc straight downflow surface type. Each contains 50,000 sq.ft. of surface, or 1⅔ sq.ft. per kilowatt of generator rating. Wide fluctuations in the river level made this construction desirable. The generating units were placed above the highest point which the river reaches and the condensers low enough to avoid lifting the cooling water at low stages. One of the unique features of the installation is a mercury expansion joint to take care of the vertical expansion in the condenser and the exhaust pipe from the turbine, which is 13 ft. diameter and 40 ft. long.

Following general practice in the steam end of large stations, the electrical connections have been arranged on the unit plan. A ring bus is employed. Each generator supplies its particular section of the bus and the corresponding feeders. Between each unit section is a bus reactance with a short-circuiting switch so interlocked with the generator switch that it will close when the latter opens and cut out the reactance. Owing to this provision only one reactance can intervene between running generators and the voltage troubles that might ensue if the current from one section of the bus should pass through several reactances in series, are eliminated. This design and layout is original and it is believed to be the first of its kind.

Another bulk station distributing in quantity to substations has been made ready for service in Cincinnati. Two 25,000-kw. units are now in place, and there are plans for an eventual capacity of 200,000 kw. The design follows closely that at Windsor. The boiler-room arrangement is much the same, with the addition that natural-gas burners are installed in the rear wall of each boiler, so that gas or coal may alternate as fuel or the two may be used in conjunction. For the same reason as at Windsor the condensers and auxiliary equipment are located in pits, the condensers, however, being of the vertical rather than of the horizontal type. In the electrical end the same ring system of bus connection is employed.

A third plant that will have a probable total capacity of 200,000 kw. is under way in Kansas City. Here again the general design is similar to the two plants previously cited. There will be an innovation in the economizer, which is to be divided into a high-pressure element above and integral with the boiler and a low-pressure section of the usual design. Progress on this station has been delayed by the war.

At Wyandotte, Mich., the Pennsylvania Salt Manufacturing Co. has completed a modern alternating-current plant with rotary-converter transformation to direct current for electrolytic work. It is notable for the prominence given the boiler room, the profuse use of instruments and in the boiler room their convenient location on a central operating board also carrying the control for boiler auxiliaries and dampers. An unusual feature is the use of a series of eductor-type jet condensers in order that the steam auxiliaries may be operated under partial vacuum varied to maintain the heat balance. For the latter purpose electric drive of certain auxiliaries improves the flexibility.

A new station having all the modern requirements and intended for an ultimate capacity of 100,000 kw. is the plant erected recently at Miller's Ford to serve Dayton, Ohio. Two units aggregating one-quarter of the final capacity are now in operation.

MUSCLE SHOALS NITRATE PLANT

Perhaps from many angles the most interesting plant to be erected during the year is No. 2 plant of the Air Nitrates Corporation at Muscle Shoals, Ala. The installation is one of the largest made as an initial installation, and its output per year will likely be larger than that of any other plant, if not of any other system. The plant load factor will be 90 to 93 per cent.! This plant, or rather the conditions for which it was designed, are certainly the closest approach to the ideal that engineers have yet encountered. A description of the many interesting engineering features of this steam station is now in preparation by one of the *Power* staff and will cover several articles soon to be published.

In Milwaukee some interesting experiments relative to the use of powdered coal in a central station have been conducted on an initial equipment serving a 468-hp water-tube boiler. A net efficiency of 81 per cent. is reported, and the general operation proved so satisfactory that four more boilers of the same size are being similarly equipped. Apparently the installation has made a record as far as the use of powdered coal in the power plant is concerned. Burning inferior coal at high efficiency is a question of vital importance in the cost of operation. The system installed has this advantage coupled with ease of control, flexibility, uniformity and low draft requirements. In the past troubles from slag and fine ash and the high initial cost of the equipment have been the bugbears in the way of progress. At Milwaukee the slag difficulties have been eliminated. When results are available from the completed plant, data on the other two factors will be received with interest.

Things of interest have been developing relative to the utilization of anthracite culm by the powdered process. There are many reasons why this fuel may be efficiently burned in pulverized form in furnaces designed for burning it in this form. Engineers should soon solve the culm problem, for there are millions of tons of it above ground. It is too soon at this writing to go into particulars as to what has been done in the way of studies and development; but soon we will be in a position to publish some interesting information.

THE STEAM TURBINE AND AUXILIARIES

Before this country entered the war there had been a decided movement toward higher pressures and superheats to increase the temperature range of the steam and thereby improve the economy of the plant. With the steam turbine a considerable gain is possible. The physical limit of standard equipment, particularly in the boiler room, is 700 deg. and more likely below that figure. What proportion of this final temperature shall be due to pressure and what to superheat is the immediate question at issue. At first glance higher pressures offer greater opportunity for gain, but with the present designs of boiler, the increase is limited and there is need of superheat to keep down the moisture and the resulting windage and friction losses in the turbine. The tendency then is toward higher pressures with sufficient superheat to minimize condensation and the problem is to perfect boilers and turbines for pressures of 500 lb. A number of the larger plants now operate with initial temperatures of 650 to 700 deg. However, the success of such high temperatures is questioned by many competent engineers.

Bearing close relation to the foregoing question is the design of a turbine that will give safely the best results with the lowest initial investment. Limit in size in a single cylinder and peripheral velocities in the lower stages are also phases of the problem demandng attention.

During last year an unusual number of large turbines were placed in service, and the experience in operation obtained will help point the way. The most noteworthy in size at least, are the two triple-cylinder compound units, one now operating in the Seventy-Fourth Street Station of the Interborough Rapid Transit Co., New York City, the other nearly ready to operate in the plant of the Air Nitrates Corporation at Muscle Shoals, Ala. Both are of 60,000 kw. normal rating, 70,000 kw. maximum. The water rates and flexibility of these units are interesting, and we hope to treat fully of these in the articles dealing with the Muscle Shoals plant. The 60,000-kw. unit in the plant of the Duquesne Light Co. is also a noteworthy installation. Others are the 45,000-kw. cross-compound reaction turbine for the Narragansett Electric Lighting Co., of Providence, the Detroit Edison and the Public Service Electric Company's single-cylinder impulse machines each of equal capacity. With the enormous increase of capacity in impulse turbines of the single-cylinder, single-flow type, difficulties have developed in operation and as a result there has been an unfortunate chain of accidents on large machines of this type. But it should be borne in mind that war conditions have made it difficult to get uniform materials with which to build these machines, and that, as everywhere, labor conditions have not been conducive to the best workmanship. These are troubles of the moment, and, as we have frequently stated, the profession should be tolerant of these occurrences in the development of a truly remarkable type of prime mover. Comparing favorably in economy with other types, the machine has the advantage of simplicity, small weight and a price that could be correspondingly low. These features lie back of the design.

THE TREND OF TURBINE CAPACITIES IS STILL UPWARD

As to limits of capacity in turbine units, the evidence shows that the trend may continue upward rather than downward, and with success. To say that 20,000 kw. is the safe and economical limit, without qualification, is to ignore what has already been achieved.

As with other equipment, advance in condenser design has been nominal. Practically, the full output of surface-condenser manufacturers has been needed by the Government for marine installations. The necessity for conserving copper brought forth the suggestion that beginning with the present year steel tubes be placed in condensers for land uses. Expansion would be reduced by the use of steel, but it was recognized that the heat transfer through steel tubes would be considerably less than with muntz metal and that corrosion would present a serious difficulty. The signing of the armistice relieved the situation to some extent, and it is doubtful whether steel tubes will be given further consideration. Where feasible, jet condensers were installed, but there were few land plants fortunate enough to obtain condensers of any type.

In the removal of air from condensing equipment there has been a marked tendency toward the use of ejector-type apparatus, steam or water being used as the propelling medium. Light weight, lack of moving parts, small space occupied and simplicity of operation are the advantages enumerated in favor of this equipment. Development work has been going on for several years and a perfected product is now available. As a reference to apparatus of this type, mention should be made of the Worthington hydraulic air pump, the Leblanc "Multijector," the Wheeler "Radojet" and the air occluder of the Alberger Company.

Supplying boilers for ships, for war plants and for more ships, sums up the activities of the year. Quantity production and limitations on steel eliminated all pioneer work. Two years ago forced draft for chain grates was an early possibility. Experimental work, however, had to be discontinued, and the matter stands in abeyance, although developments may be expected in the year now under way.

In engineering relating to shipping a noteworthy work has been done by the United States Shipping Board Emergency Fleet Corporation. The importance of having uniform, reliable machinery aboard the enormous tonnage called for by the Board's program is obvious. A measure that will accomplish this is the standardization of all this machinery by committees including about seventy of the leading engineers of the country. The work was under the direction of John A. Stevens, as Standardization Engineer, who is well-known as chairman of the Boiler Code Committee of the American Society of Mechanical Engineers. The Boiler Code was about eleven years in the making; considering that the ship machinery standardization was completed in a matter of weeks, the dispatch of this really noteworthy work is apparent.

The zone system of distribution has focused more attention on the furnace. In those plants where a transfer had to be made from Eastern to Middle West coal, it was almost invariably the rule that the furnace volume was too small to care for the excessive volatile content and there were difficulties in removing the greater quantity of ash. Even in furnaces designed for the poorer coals of the Middle West, it was found that results could be improved by enlarging the furnace and increasing ignition by the use of more refractory material in arch and bridge-wall. For Iowa and Colorado coals volumes as high as 12 cu.ft. per square foot of grate area are no longer considered excessive. This may be compared to 6 cu.ft. as a previous standard and to volumes considerably less for coals from Indiana and Illinois.

PROGRESS IN BURNING LIGNITES

Necessity has also enforced considerable progress in the burning of lignites. Experience has shown that lignite can be burned under boiler furnaces without insurmountable difficulties, and the Bureau of Mines is sponsor for some excellent work showing how it may be done. A summary of the suggestions advanced may be obtained in an article by Henry Kreisinger, appearing in the Apr. 30 issue of *Power*. Even in peace times it is in the interest of national economics to eliminate the long hauls and the attending expense common in the coal trade. Industries adjacent to the lignite fields should investigate the possibilities. When stokers, furnaces and methods have been adapted to this fuel, a reduction in operating expense is more than probable and transportation will be relieved of an unnecessary burden. To provide furnaces and stokers of proper design is up to the manufacturer. Some already have information to supplement the work of the Bureau, so that rapid progress may be expected.

While no specific information is available for publication at this time, the year has witnessed much thought devoted to the problem of extracting the many chemicals from the volatile matter in coal before its use in boiler furnaces. Here is an interesting field and one pregnant with great possibilities because the heat value of coal will be decreased but little by the extraction of the volatile content. We are of the opinion that it will be inadvisable to entirely remove the volatile, for then combustion difficulties would likely arise.

Interesting experiments are to be carried out to ascertain the value of methane, or the gas commonly known as firedamp, as a fuel. There are millions of cubic feet of methane drawn from coal mines by the ventilating fans and this gas has been discharged to the atmosphere for years without any attempt being made to ascertain if it is adaptable for use in boiler furnaces as an aid to combustion. At the Loomis colliery of the Delaware, Lackawanna & Western Co., an experimental station has been erected for the purpose of determining the value of methane in mine air by introducing it into a boiler furnace, instead of taking air from the atmosphere. A comparison of results obtained by using methane air in the boiler furnace and that from the atmosphere will give the value of using mine air. Another problem to be solved is whether the return air from the mine containing 1 per cent. of methane and less oxygen than pure air can produce greater heat from the coal consumed than can be obtained with pure air. The results of the Loomis experiments to be obtained are problematic, but they will be highly interesting to mine-plant engineers.

WATER-POWER DEVELOPMENTS

Owing to the shortage of coal and the excessive demand for power, special efforts were made to speed up action in the House of Representatives on the passage of water-power legislation. Very early in the year President Wilson turned over to this body a new water-power bill, known as the Administration Bill, in which attempts had been made to coördinate water-power legislation proposed for several years past in both Houses of Congress, not only on the public domain, but in navigable streams as well. The bill provided for a water-power commission to be composed of three Cabinet officers and for an executive officer of the commission to be appointed by the President for five years. A House committee of eighteen was appointed to compose differences as to the various bills that had been under consideration and facilitate if possible the passage of the new bill. Altogether this bill appeared to be a great improvement over former attempts, although it was not without objection. Repeated hearings of the special joint committee resulted in many changes in the original draft of the bill, three entirely new sections and several practically rewritten. It was eventually licked into shape for action by Congress, but the bill got no further and is still up for passage.

During the year hydraulic power already installed was utilized to the fullest extent, and the plans for interconnection were carried out where feasible. At Niagara it was proposed to consolidate the three large power companies and by an expenditure of $15,000,000 erect an additional plant that would increase the output by 170,000 hp. The request came from the War Department as a necessary war measure to provide sufficient power for war industries in and about Buffalo. There were many other plans for interconnection, including the erection of enormous stations as links in the chain, but the early ending of the war made the carrying out unnecessary at least for the time being. In California all systems are now tied together for exchange of power. In the Southeast they were already connected in this way. Systems under different management in Washington and Idaho have also been linked together. In Montana eight hydro-electric plants are successively using the same stream flow. Not only the natural flow but the storage water as well is effectively utilized by each plant. In this system the annual load factor is 75 per cent. and the mean monthly load factor, 80 per cent. It is evident that interconnection of hydro-electric plants makes for greater effective use of variation in rainfall, as different watersheds are thereby brought to serve a common system. The statement has been advanced by E. W. Rice, Jr., that the useful output of groups of large systems may through interconnection be increased 25 per cent. This was made possible by the saving in reserve equipment, improvement in load factor and the diversity of the different loads.

An incident of the year was the turning over for the first time of the 25,000-hp. Francis turbine in the White River generating station of the Puget Sound Traction, Light and Power Company. It is the most powerful high-head (440-ft.) turbine of its type in the world and is practically a duplicate of the two 18,000-hp. machines placed in commercial operation in the same plant in 1911. Fifty per cent. of the additional power will be supplied to the Coast Division of the Chicago, Milwaukee & St. Paul Railway. It will be delivered at 100,000 volts and be converted into direct current of 3000 volts for use in the motors of the electric locomotives.

The enormous water power available from the Tennessee River is now, perhaps, nearer actual development than it has ever been. Its development will certainly open up a region in the South where industrial possibilities will be exceptionally favorable because of the cheap power, and the resources in raw materials. The country is justified in expecting the development of this water power without delay.

THE ELECTRICAL FIELD

Last year and in fact for several years there has been no material improvement in the efficiency of electrical units such as generators, motors and transformers. Efforts to increase the economy have been transferred from the unit to the system, where maximum use of generating and distributing equipment is the all-important problem, calling for intensive study of load factors of generators, stations and the systems as a whole and careful consideration of the diversity factor. Reduction of constant and no-load losses and the use of synchronous equipment to reduce the idle currents also enter into the problem. As a result of study along these lines automatic substations are being installed, stations of a system are being tied together and transmission lines of different systems are being interconnected as previously indicated in the section under water power. There has been marked improvement in over-all efficiency, but there are still plenty of opportunities for further gain.

There has been decided progress in electrical furnaces. In the last year the number employed has practically doubled, and there are over five times the number that existed five years ago. War demands have, of course, been partly responsible, although with the electric furnace it is now possible to produce steel at a cost comparing favorably with openhearth production, and obtain a better product, due to the exact and easy regulation that is possible. Single-phase furnaces are losing prestige to the three-phase type, by reason of the more desirable load characteristics of the latter.

A MORE STURDY TUNGSTEN LAMP

A product of the year is a new tungsten lamp more sturdy than the present design. From a steel supporting rod the filament is braced at four different points. As a consequence it is not nearly so fragile as the present tungsten and full advantage can be taken of the high efficiency offered by this type of lamp without undue breakage. It is a product of the committee on war service of the Illuminating Engineering Society and is considered one of the best things that it has accomplished.

Scarcity of copper and steel set engineers to thinking of substitutes: for example, steel tubes for condensers and reinforced concrete for steel beams and columns in the power plant. A case in point is the new 15,000-kw. Buffington, Ind., power plant of the Universal Portland Cement Company.

On the electric light and power industry war effects were heavy increases in operating costs and excessive prices for plant equipment to take care of the rapidly increasing demand. For 1918 the output of central stations was nearly 75 per cent. greater than in 1914. The price of coal has practically doubled, and the average advance in labor is at least 25 per cent., this to be coupled with scarcity of men competent to maintain high standards of efficiency. Over the pre-war level, prices of hydraulic machinery are reported to have advanced from 100 to 150 per cent.; electrical apparatus, from 125 to 150 per cent.; steam-turbine generators, 150 per cent., and water-tube boilers, 170 per cent., with uncertain and in most cases long delayed deliveries.

To help carry the increased load, interconnection and pooling to a limited extent have helped. During the year for the most part it has been necessary to get along with the equipment on hand, using it to the maximum, and as might be expected in times of stress, suffering an unusual number of accidents. There have been many boiler explosions, economizers have let go, turbines and flywheels have been wrecked and even generators have exploded. A recent case of the type of accident last named was the generator wreck in the St. Paul plant of the Northern States Power Company; the generator was, however, of a type long ago abandoned by the builder.

THE ENGINEER IN A NEW ROLE

The engineering profession is coming into its own. The war has done much to change the attitude of the engineer toward affairs of state and the public welfare generally, and of equal importance, the public is beginning to realize the true importance of the engineer and his relation to public work. It has been an engineer's war from start to finish. The Government early realized this and has called continuously for assistance and advice. Even in matters of legislation the Government has asked for guidance. In the old days such procedure was unheard of, and the engineer, with an aversion to publicity, even of the most reserved character, was apparently content to allow the lawyer and the politician to take his place in the sun. As previously intimated, the war has changed all this. As a duty to the public and to his own profession the engineer has at last come to realize that in addition to the actual doing of engineering work, he must guide legislation, relating to his field, along proper channels, and that publicity, giving credit for engineering accomplishment where credit is due, is the thing needed to raise the profession in the eyes of the public. Through the coördination of the great engineering societies of the country to more effectively serve the Government, the engineer has also learned the value of coöperative effort. It is an excellent introduction to the new rôle the engineer is destined and so well qualified to assume in the future. In this development engineering education will have an important bearing, and in this connection the studies along this line of Dr. Charles R. Mann under the joint auspices of the Carnegie Foundation for the Advancement of Teaching and the Joint Committee on Engineering Education of the national engineering societies, is worthy of the most serious consideration.

It is gratifying to record the additional $100,000 donated the Engineering Foundation for endowment of engineering research by Ambrose Swasey, of Cleveland. In 1915 he gave $200,000 for this purpose, so that his gifts now total $300,000.

To meet the new need for an agency to aid engineers who have been in military service to find suitable positions, the Engineering Council has established an Engineering Societies Employment Bureau, with headquarters in the Engineering Societies Building, New York. It is to continue the excellent work that the American Engineering Service rendered the Government during the war. The movement is an indication of the trend toward helping the young engineer by taking a paternal interest in his welfare in addition to offering him the advantages of education and association that membership previously held.

POWER-PLANT LEGISLATION

In legislation pertinent to the field, some modifications in boiler rules relative to safety of construction and operation have been made to meet temporary war conditions. No additional state license laws have been passed. The emergency power act was a notable bill recently passed. The provisions conferred vast power upon the President, authorizing him to provide sufficient power for war work by taking control of existing plants or adding to their capacity, by building new plants, by consolidating power systems or by diverting power from one industry to another. It was a war measure warranted by the conditions at the time of its passage. The early signing of the armistice made enforcement unnecessary.

THE HONOR ROLL FOR 1918

First place goes to the engineers who made the supreme sacrifice for their country. Those who came back will receive the honor due them as will the men who stayed at home and gave their best efforts in backing up the troops at the front. Mention should be made of the award of the eighth Edison Medal to Dr. John J. Carty, colonel in the United States Army Signal Corps and chief engineer of the American Telephone and Telegraph Co. The recognition was due to meritorious achievements in the science and art of telephone engineering. Other scientists previously honored in the same way were Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell and Nikola Tesla. Engineering societies closely related to the field honored the following men with the presidencies of their respective societies: Mortimer Elwyn Cooley, American Society of Mechanical Engineers; Comfort A. Adams, American Institute of Electrical Engineers; W. F. Wells, National Electric Light Association; Roderick Mackay, National Association of Stationary Engineers; George E. Wells, American Society of Refrigerating Engineers; Fred R. Still, American Society of Heating and Ventilating Engineers; Charles F. Rand, United Engineering Society; J. Parke Channing, Engineering Council.

NECROLOGY

A number of men of prominence in the field passed away during the year. The columns of *Power* record the following: Christopher W. Levalley, founder and chairman of the board of directors of the Chain Belt Co.; F. G. Rollins, late president of the Holmes Metallic Packing Co.; Adam Cook, senior member of the firm of Adam Cook's Sons; John P. Sparrow, chief engineer of the New York Edison Co.; Charles Jenkins, at one time member of the firm of Jenkins Bros.; E. C. Meier, president of the Heine Safety Boiler Co.; Frederic Remsen Hutton, well-known engineer educator and distinguished member of the American Society of Mechanical Engineers; Frank J. Corbett, vice-president and secretary of the Bergen & Linderman Co.; Charles Allis, second son of the late Edward P. Allis; George William Dickie, naval architect and marine engineer; William Kent, eminent engineer and author of many technical books; William Allis, at one time chairman of the board of directors of the Allis-Chalmers Manufacturing Co.; Lieut. Charles R. Seed, superintendent of power of the Worcester Electric Light Co.; Charles F. Simms, for many years manager of the Omaha office of H. W. Johns-Manville Co.; Martin W. Kern, mechanical engineer of the Narragansett Electric Lighting Co.; Edward Allan Wickes, president of the Niagara Falls Power Company.

Thermometer as a Boiler Blowoff Indicator and Tank Counter

By George W. Caywood

Some time ago there was published in *Power* a description of an apparatus consisting of a check valve located in the blowoff pipe and connected to a clock-operated chart to indicate when the boilers were blown down. (See page 744, Nov. 28, 1916.) Since then other devices, more or less complicated, have been described.

At the steam plant of the Minneapolis Street Railway Co. we have found that a recording thermometer is valuable for this purpose. All blowoff pipes are connected to one 6-in. main. The thermometer bulb is placed in this pipe, inside a short nipple, to protect it from damage by the rapid passage of scale or other matter when blowing down. We have also found it valuable as an indicator of the condition of the blowoff valves.

The chart, Fig. 1, shows the temperature of the blowoff pipe at normal condition; it also shows at what time the boilers were blown down and that the recording pen returned to its normal position, indicating that all valves were closed tight. Should a bad leak develop, the chart would show an increased temperature. In fact this did occur and it was found that the blowoff valve on No. 15 boiler was leaking.

For boiler-test work a horizontal cylindrical tank is utilized to measure the water used. About midway in the vertical height is placed a standard mercury thermometer, also the bulb of a recording thermometer. On this we use a chart making one revolution in twelve hours, as a fast-moving chart results in a plainer diagram. This is especially desirable when high-capacity tests are run. This chart indicates each time the tank is filled and emptied and also shows the temperature of the water. The chart, Fig. 2, shows that the test began at 8:50 a.m. and ended at 4:51 p.m., and that 68 tanks of water was used. We do not depend on this alone for our records, but it is an excellent check on the men whose duty it is to keep a record of the temperature and the amount of water used.

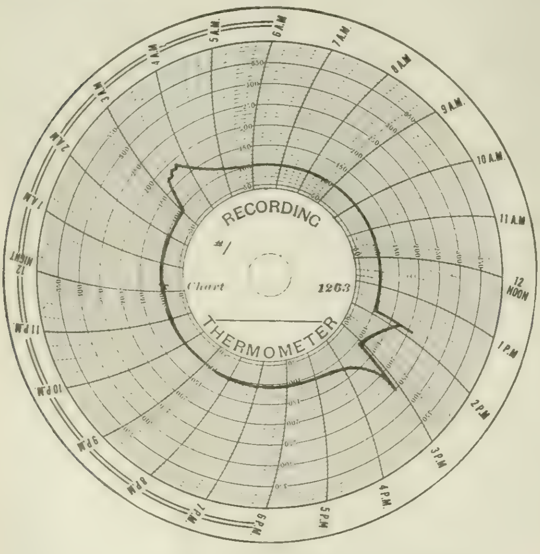


FIG. 1. BLOW-OFF TEMPERATURE CHART

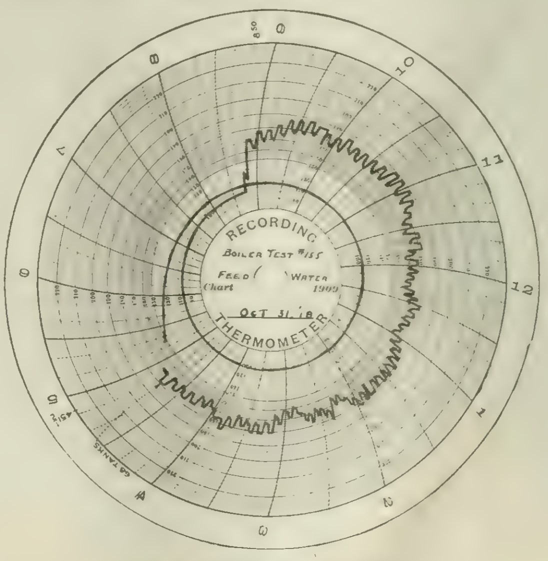


FIG. 2. TANK-FILLING CHART

Properties of Liberty Fuel and Results of Economy Tests

FURTHER particulars as to the nature and characteristics of the new Liberty fuel invented by Captain Weisgerber are now available. As stated in the Dec. 17, 1918, issue of *Power*, kerosene is the base of the new fuel. It is treated with a chemical, with the result that its oxygen content is increased, so that when the fuel is vaporized and admitted to the engine cylinder there is present some of the oxygen needed for the process of combustion.

The quality of Liberty fuel is under close control during the manufacturing process and may be regulated at will. The curves given in Fig. 1 show the relation between the temperature and the percentage of the sample driven over, during distillation tests of three different qualities of fuel, designated as *A*, *B*, and *C*.

Liberty fuel has a variable specific gravity according to its varying quality. The gravity may run from as low as 35 deg. Baumé to as high as 72 deg. Baumé. The heat value per gallon is 127,900 B.t.u. as compared with 119,200 B.t.u. for commercial gasoline and 112,300 B.t.u. for export gasoline.

Tests were made on a 150-hp. Hispano-Suiza engine to determine the relative performances of Liberty fuel and export gasoline. The results of these tests are indicated graphically by the curves in Fig. 2. It will be observed that Liberty fuel gives a higher thermal efficiency and a greater brake mean effective pressure than export gasoline. A greater weight but a smaller volume of the new fuel is required than of export gasoline to produce one horsepower-hour, the explanation being that the Liberty fuel weighs more per gallon than gasoline, in the ratio of about 7 to 5.9.

The chemical treatment to which the basic kerosene is subjected apparently transforms the heavier hydrocarbons into lighter ones, thus rendering the fuel easier to vaporize in the carbureter. As it carries with it some of the oxygen required for combustion the flame propagation is more rapid, resulting in a greater explosive effect.

According to the inventor, the temperature of the exhaust gases is about 140 deg. C. lower for Liberty fuel than for ordinary gasoline. This may be explained on the ground that the initial pressure is higher, the combustion period shorter and the exhaust temperature therefore lower; or, the presence of oxygen in the fuel enables a leaner mixture to be used, which would tend toward cooler running conditions.

The first Liberty fuel was made in small glass retorts in a laboratory. Later, when larger quantities were desired, it was necessary to procure a large still; but the largest that could be obtained was a 3-gal. gin still. Liberty fuel has been compounded for tests in a large number of different makes of motor cars and, according to the inventor, has shown from 10 to 62 per cent. increase of mileage over gasoline. It has also been tried out in airplane and tractor motors with entire success. This fuel was developed in order to take care of the anticipated shortage of gasoline during the spring of 1919, with the idea of rendering kerosene available for internal-combustion engines of all types. The claim is made that the cost of the kerosene plus the cost of the chemicals and the expense of treating will amount to a little less than the cost of gasoline, though not materially less.

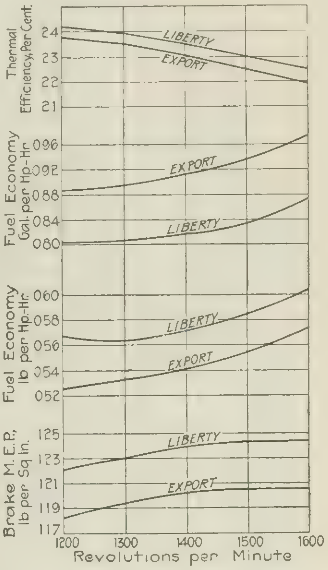
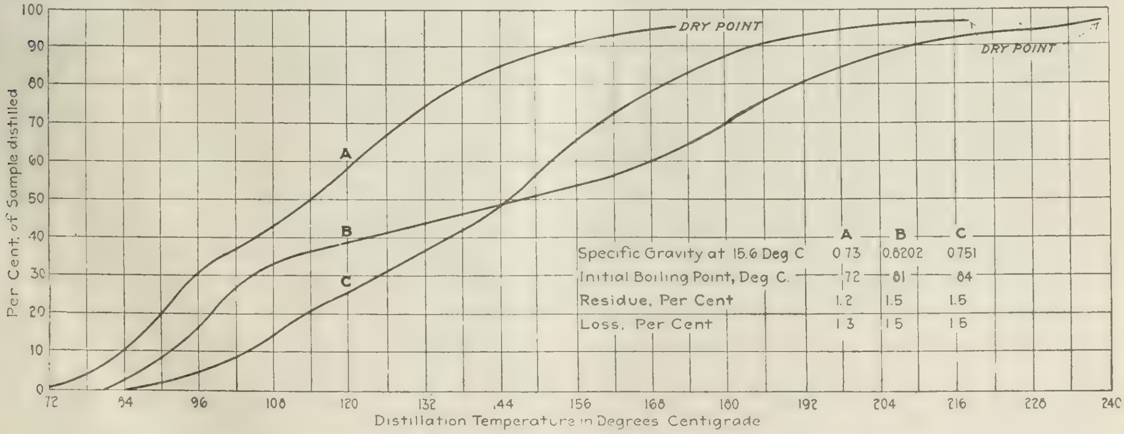


FIG. 2. RELATIVE ECONOMY OF LIBERTY FUEL AND EXPORT GASOLINE



	A	B	C
Specific Gravity at 15.6 Deg C	0.73	0.8202	0.751
Initial Boiling Point, Deg C.	72	81	84
Residue, Per Cent	1.2	1.5	1.5
Loss, Per Cent	1.3	1.5	1.5

FIG. 1. DISTILLATION CURVES OF DIFFERENT GRADES OF LIBERTY FUEL

Reconnecting Induction Motors—For Change in the Number of Poles—III

By A. M. DUDLEY
Designing Engineer, Westinghouse Electric and Manufacturing Company

Reconnecting for changes in poles. The effect on the shape of the magnetic field of changing the throw of the coil and how reconnecting a given winding for different numbers of poles has the same effect as changing the throw of the coil.

IN THE article published in the issue of *Power* for Apr. 9, 1918, it was shown that it is possible to reconnect a given stator winding for different numbers of poles or speeds, and the method of determining the proper operating voltage for each such speed was explained. In the issue of Aug. 20 there was shown a method of plotting a physical representation of the rotating magnetic field as it varies from point to point around the air gap of an actual machine. It is the purpose of this article to show how reconnections of the stator windings affect the shape of the magnetic field and at the same time to show what effect is produced on its shape by changing the throw of the coil, or chording the winding as it is called. The latter effect will be investigated for a change of one slot at a time from full pitch to less than half pitch. By full pitch is meant that the span of the coil is exactly the same distance as that from the center of a north pole to the center of an adjoining south pole, and by half pitch that the coil spans or throws only half that distance. Referring to Figs. 9 and 10 of the article of Aug. 20 the small "stair step" figures represent cross-sections of the magnetic field existing in the motor as the alternating currents in the windings vary in value from instant to instant, and a comparison of the small figures shows that the magnetic field actually travels around the stator bore or "air gap" at a uniform rate. The number of revolutions that it makes in one minute is equal to 120 times the number of cycles per second of the supply circuit divided by the number of poles in the stator. Expressed in symbols this would be $S = 120\,\frac{f}{p}$; where S is the speed of rotation in r.p.m., f is the frequency in cycles per second, and p is the number of poles.

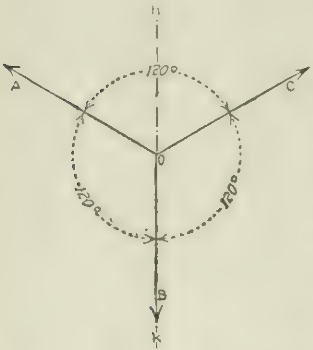
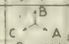
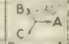
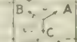
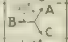
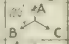
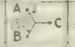
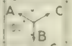
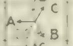
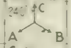
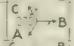
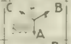
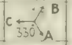


FIG. 1. VECTOR REPRESENTATION OF THE CURRENTS IN A BALANCED THREE-PHASE SYSTEM

In order to make clear the field photographs or diagrams of the present article and to obviate the possibility of confusion regarding them, attention is called to the fact that they represent the conditions existing in the windings at an instant of time when the current in one of them is at its maximum value. Since we are dealing with three-phase motors, the currents in the windings connected to the other two phases will at that instant both be equal to one-half their maximum values. This may be explained by reference to Figs. 9 and 10 of the article of Aug. 20, which represent the values of the currents in the three phases for every 30 deg. of a complete cycle of 360 degrees. Suppose these three currents are represented by the three branches, *A*, *B* and *C* of the "Y" illustrated in Fig. 1, each of which is 120 deg. from the other, and that a vertical reference line *hk* is drawn through the center *o*. Now assume that the "Y" rotates in a counterclockwise direction about this center while the line *hk* remains stationary, and that the three branches assume the successive positions represented in the second column of Table I. The values of the currents at any instant of time will be represented by the length of their horizontal projections upon the line *hk*. If the maximum value of each current is assumed to be one ampere, the instantaneous values of the three for each 30 deg. of a complete cycle would be those given in the last three columns of Table I. Projections that lie above the center *o* are taken to be positive and those that lie below as being negative.

TABLE I. INSTANTANEOUS VALUES OF THE CURRENTS IN A BALANCED THREE-PHASE SYSTEM AT INTERVALS OF 30 DEG DURING A COMPLETE CYCLE, BASED ON A MAXIMUM VALUE OF 1 AMP.

ANGLE DEG	POSITION OF BRANCHES OF Y	CURRENT A AMPERES	CURRENT B AMPERES	CURRENT C AMPERES
0		-05	+10	-0.5
30		0	+0866	-0.866
60		+05	+05	-10
90		+0866	0	-0866
120		+10	-05	-0.5
150		+0866	-0866	0
180		+05	-1.0	+05
210		0	-0866	+0.866
240		-05	-0.5	+1.0
270		-0866	0	+0866
300		-10	+05	+05
330		-0866	+0866	0
360	Same as 0 Deg			

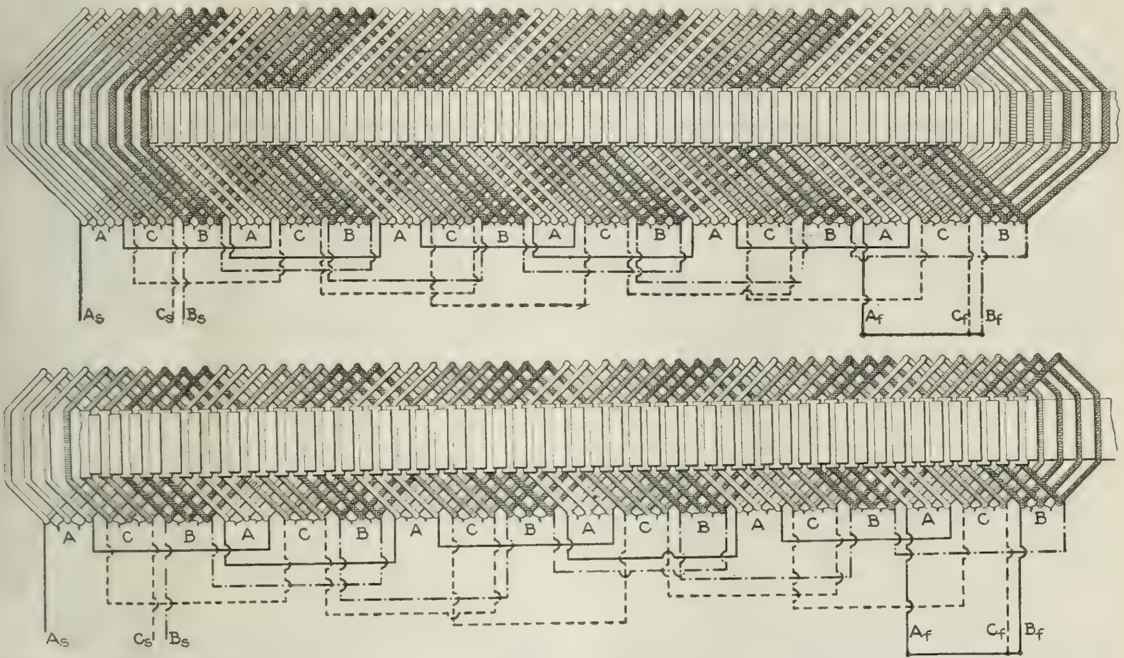
In the previous article there was given a picture of the field corresponding to each instantaneous value of the currents, but in the present article the figures are given for only one of these values and they have been chosen to be the ones existing when the condition is that shown for 0 deg. in Table I; that is, for the instant when the current in the *B* phase is at its plus maximum value and the currents in the *A* and *C* phases are at minus one-half their maximum values. Of course, any other position could have been chosen for conducting the investigation, but the values for the 0 deg. position are convenient ones to use when plotting the results.

Since one of the effects of reconnecting for a different number of poles is to affect the "chord" or throw of the coil, let us consider first the effect of "chording." A reference to the article on "Fractional Pitch Windings" in the issue of July 31, 1917, will be helpful in understanding the figures which immediately follow. Figs. 4 to 9 inclusive show the magnetic field constructed, as explained in August article, for a 54-slot three-phase 6-pole winding when the throw of the coil is changed one slot at a time from slots 1 and 10, as in Fig. 2, which is full pitch or 180 deg., down to slots 1 and 5, as in Fig. 3, which is less than half pitch; or to be precise, 80 deg. The same magnetizing current is assumed to flow in the coils in all six cases, although in an actual machine this would not be the case; the magnetizing current would increase with decreased throw of coil due to the attempt of the motor to keep the field at the constant value necessary for the generation of the required back or counter-electromotive force. To facilitate comparison, however, this change in current has been disregarded in the figures. The "stair steps" show the magnetic fields as they would look if there were no winding on the rotor, and the smooth curves, having the sine shape, show the fields as they look after being smoothed out by the currents in the rotor winding. It will be noticed that the area of the field for one pole is given in each case and that it varies from 32 for full pitch in Fig. 4, down to 20 in Fig. 9. These areas correspond to what is known as the "chord factor" of the winding. In the article on fractional pitch it was stated that the chord factor for a chorded winding could be expressed in its effect on the magnetizing or no-load current and in its effect on the generated or counter-electromotive force by the mathematical value of the sine of one-half the electrical angle spanned by the coil. This relation is shown in the following table:

TABLE II. CHORD FACTORS FOR VARIOUS ANGLES

Figure	Angle Spanned by Coil = a Deg	Sine ½a, or Chord Factor	Area of Magnetic Pole Figured from Chord Factor	Area of Magnetic Pole Graphically from Figure
4	180	1 000	32.0	32
5	160	0 985	31.5	31
6	140	0 940	30 1	30
7	120	0 866	27 7	27
8	100	0 766	24.5	24
9	80	0 .642	20 5	20

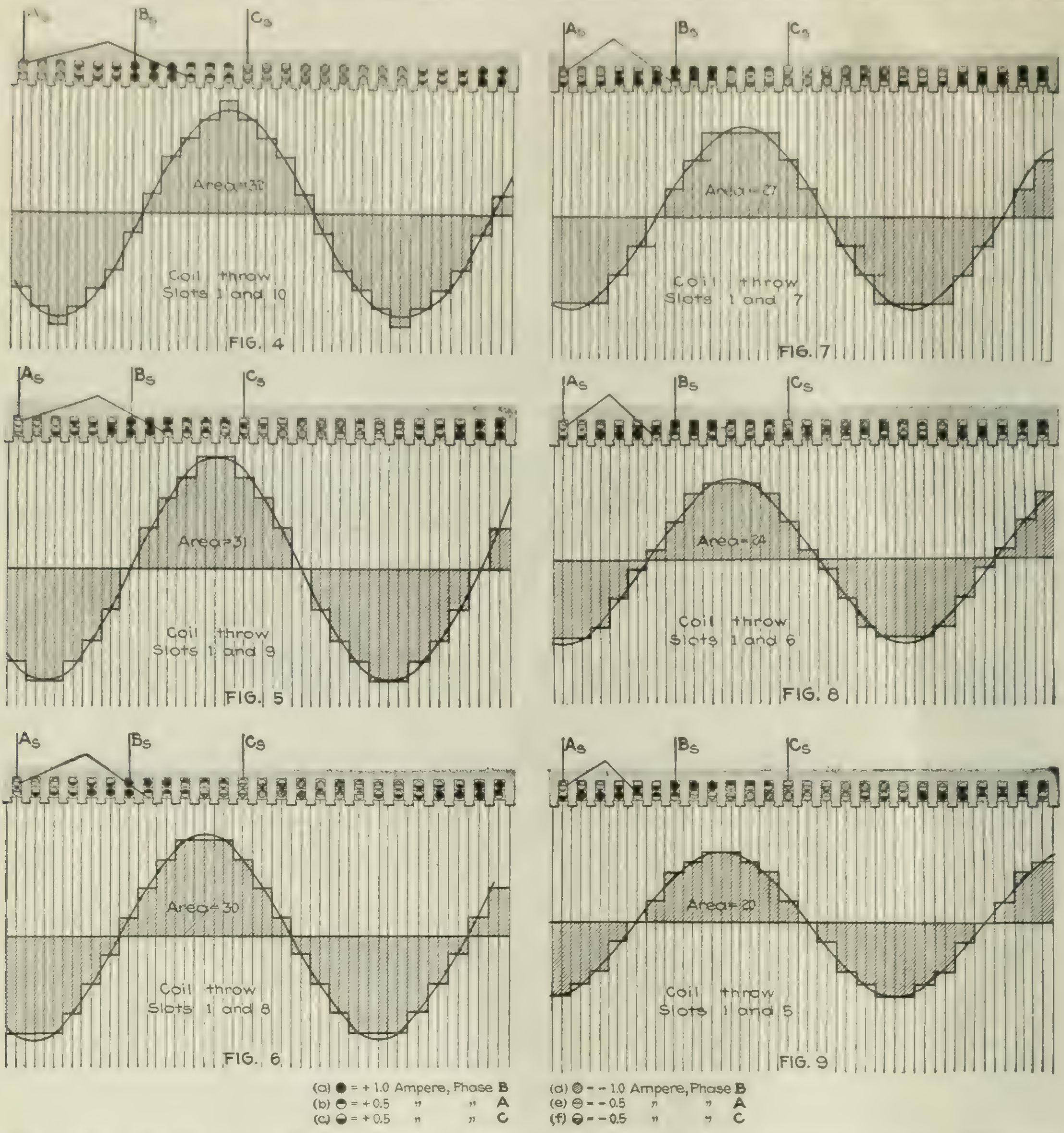
The slight difference between the last two columns in the table is due to the area under the "stair step" curve not being quite the same as the area under the corresponding smooth sine curve. The chord factor as shown in the third column at once indicates two facts: First, that if the winding is chorded more current will have to flow in the windings to produce the same magnetic field strength; and second, that since the generated or counter-electromotive force in the windings set up by the rotating magnetic field is reduced through chording by the amount indicated by the chord factor, it is necessary to have a stronger magnetic field in the motor if it is to operate at the same voltage when the coil is chorded up. The way this shows up in reconnecting for different numbers of poles, when the reconnection causes chording of the coil, is that the same effect is produced as would be if the motor were connected to a higher voltage. This will be explained fully in a later article dealing with the practical application of the principles presented in this series to the actual work of reconnecting.



FIGS. 2 AND 3. WINDINGS OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR CONNECTED FOR FULL OR 180 DEG. PITCH AND FOR 80 DEG. PITCH

A_s, B_s and C_s indicate the start and A_f, B_f and C_f the finish of the windings for the three phases

An examination of the shape of the magnetic field indicates that the effect of chording is to flatten the top of the field and make it lower for the same pole span. In Fig. 10 is shown the effect of connecting the winding of Figs. 2 and 4 for four poles instead of six. The mechanical throw of the coils is still 1 and 10, but the pole arc is longer for four poles, hence, the coil is actually chorded to 120 electrical degrees for four poles, although it was full pitch, or 180 deg., when connected for six poles. It will be noted that with the 6-pole winding, Fig. 4, the entire area of the poles is 6 × 32 = 192, but that for the 4-pole winding, Fig. 10, the area is 4 × 61 = 244. In the 4-pole winding, the speed of the rotating field is 1.5 times that of the 6-pole one, and it would therefore seem reasonable that with the same magnetic field density in the air gap and the same currents in the windings, the horsepower when connected as a 4-pole machine should be 1.5 times that of the 6-pole rating. However, since the coil throw on four poles is only 120 deg. the chord factor is sine of 60 deg. = 0.866 and the rating will be reduced by this fact so that only 1.5 × 0.866, or about 1.3 the 6-pole horsepower can be expected. The total areas of the two fields as previously noted—namely, 244 and 192—have the relation $\frac{244}{192}$ = 1.27, which is very close to 1.3, so it follows that a close aproximation of the output to be expected from a reconnected motor can be



FIGS. 4 TO 9. SHAPES OF MAGNETIC FIELDS OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR WHEN THE THROW OF ITS COILS IS CHANGED FROM SLOTS 1 AND 10 TO SLOTS 1 AND 5 BY ONE-SLOT INTERVALS

Explanation of symbols used: *e*, *a* and *f* are the instantaneous values of the currents in phases *A*, *B* and *C* respectively, for angle 0 deg. as given in Table I. It is assumed that positive currents flow toward the reader and that negative ones flow away from him; the former are represented by the solid black symbols, and the latter by the hatched ones. When the currents *e*, *a* and *f* make their return through the other side of the coils their direction in reference to the observer is reversed and they are then represented by the symbols *b*, *d* and *c* respectively.

obtained by this simple method of plotting the magnetic fields and comparing the areas. The difference in the saturation of the stator iron would affect this result to some extent, but usually not enough to introduce a serious error.

In Figs. 11, 12 and 13 is shown the effect upon the magnetic field of reconnecting the winding shown in Figs. 2 and 4 for 8, 10 and 12 poles, respectively. The effect of chording becomes more pronounced with each step, and the decreased area of the magnetic field shows that with the decreasing speed the horsepower decreases also until finally in Fig. 13 an impossible condition is reached under which the motor could not run at all, since the throw of the coil is exactly pitch for 6 poles and therefore substantially becomes dead when connected for 12 poles; or putting it another way, the throw of the coil is such that when there are 12 poles both sides of any given coil lie in exactly the same polarity; one side is under a north pole and the other, instead of being under a south pole, reaches clear across and lies under the next north pole, so that the counter-electromotive force, which is generated in one side of the coil, is exactly balanced and neutralized by the voltage generated in the opposite side and there is no counter-electromotive force left to oppose the applied electromotive force at the stator terminals, consequently, the current in the stator winding is limited only by the ohmic resistance of this winding, and would cause the circuit-breaker to open, or, if the motor was not properly protected, cause the windings to be destroyed in a very short period. Attention was called to this point in an earlier article when speaking of the possibility of connecting some windings as they stand for double or half speed; that is, for half as many poles or twice as many poles. The statement was then made that this should not be attempted if the throw of the coils was exactly pitch on the original winding. Fig. 13 explains why this is true and why such a reconnection is not feasible.

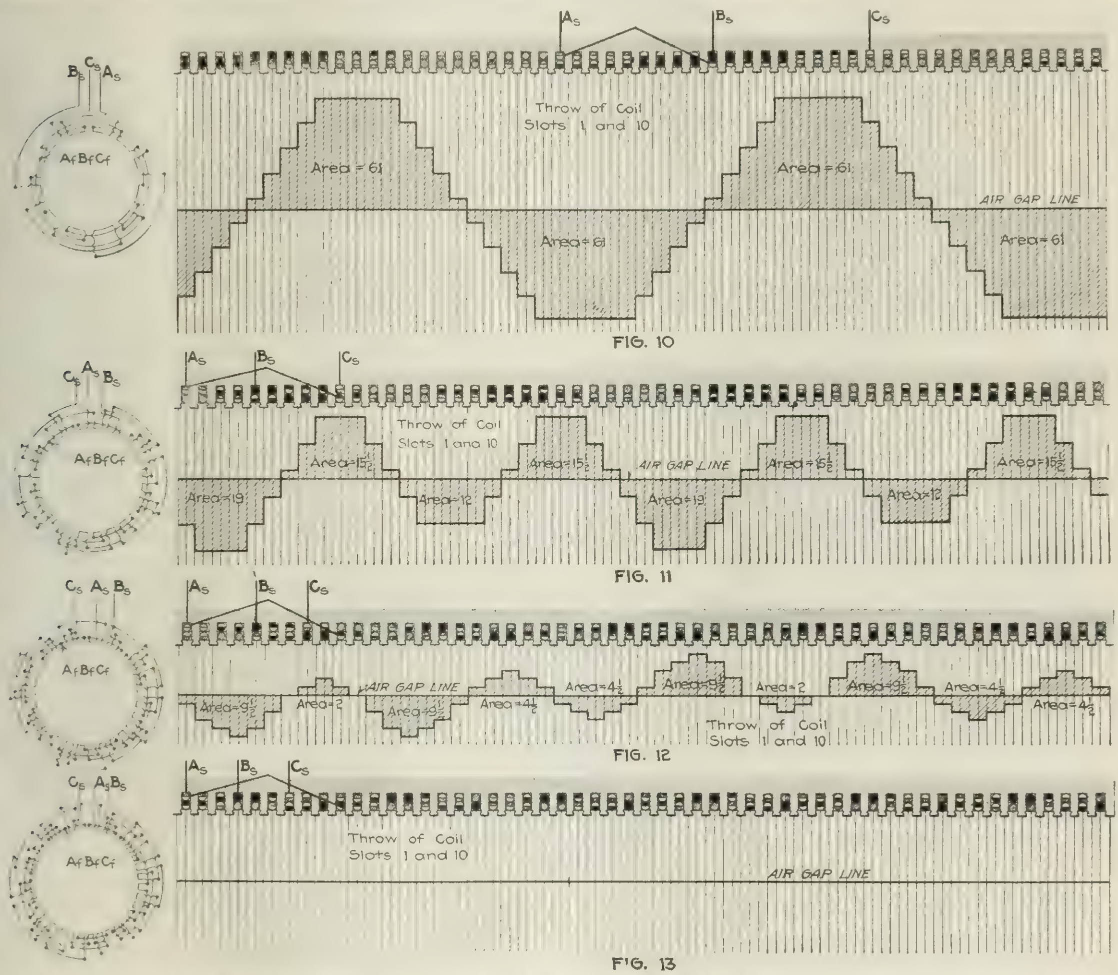


FIG. 10

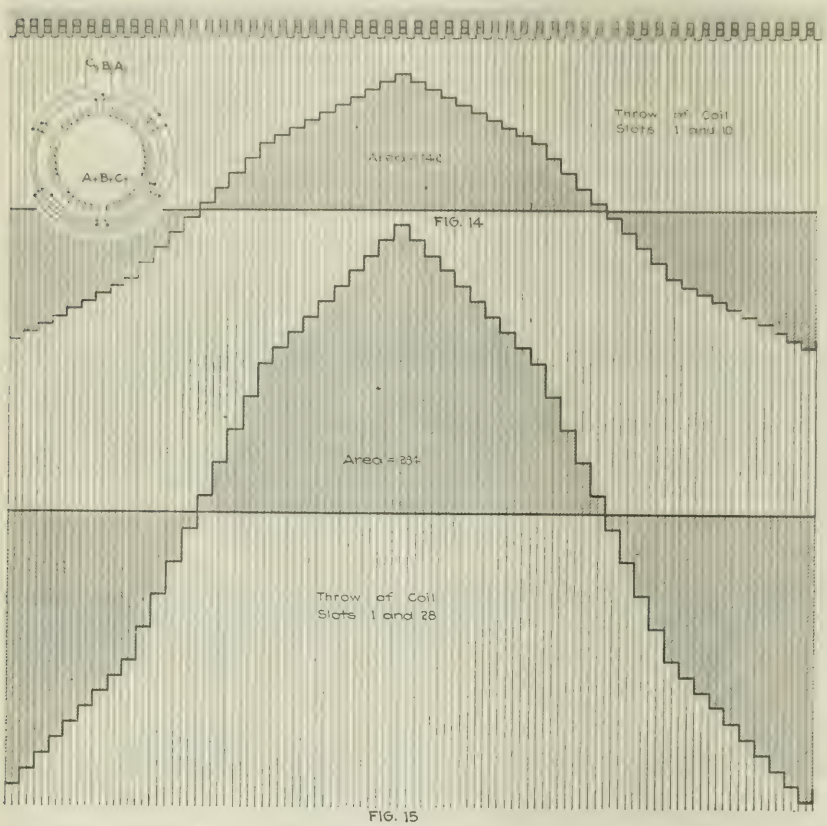
FIG. 11

FIG. 12

FIG. 13

FIGS. 10 TO 13. SHAPES OF MAGNETIC FIELDS OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR OF A COIL THROW OF SLOTS 1 AND 10, WHEN RECONNECTED FOR 4, 8, 10 AND 12 POLES

In Figs. 14 and 15 is shown a very interesting comparison. Fig. 14 shows the result of reconnecting the 6-pole winding of Figs. 2 and 4 for two poles. Ordinarily, this would not be possible because a 2-pole motor would require about three times the radial depth of iron behind the slots as is required by a 6-pole one; but assuming for illustration that such a reconnection had been attempted, the field would have the appearance shown, and it will be seen that the area of one magnetic pole would be 142. Suppose, on the other hand, that instead of reconnecting, the motor had been rewound with coils having a throw of 180 deg. for two poles or full pitch, as shown in Fig. 15; then the area of the field would be 284 for one pole or just twice the value for the reconnected motor. Since, as has been shown, the comparative areas of the two poles are some measure of the output to be expected, it can be at once concluded from Figs. 14 and 15 that the use of a new set of coils would double the output of the motor and that it would be poor economy in such a case to reconnect instead of rewinding.



FIGS. 14 AND 15. MAGNETIC FIELD OF A 54-SLOT THREE-PHASE 6-POLE INDUCTION MOTOR OF COIL THROW 1 AND 10, WHEN RECONNECTED FOR TWO POLES, COMPARED WITH EFFECT OF REWINDING IT FOR TWO POLES WITH A THROW 1 AND 28

This paper completes the subject of reconnecting for changes in poles, and from the figures given it may be seen that the first consideration in such changes is the question of chord factor, and the comparisons made give a good idea of the effect upon any motor of changing the throw of the coil. The main value of the latter idea is that it is often possible when reconnecting a winding to assist in getting normal conditions in the winding by changing the throw of the coils by a slot or two in a certain direction.

Extreme temperatures are destructive of furnace lining. Perhaps this is why so many firemen are so careless regarding the admission of excess air to their furnaces.

Destruction of the French Coal Mines*

The French Departments du Nord and Pas-de-Calais have suffered severely through the depredations of the invader. The Germans, in their customary manner, destroyed the greater part of the machinery used at the coal mines. As a result of their ruthlessness, France is deprived of one-third of her normal output of coal for a period of three or four years to come. Whether the German debt shall be paid by occupying the district of La Sarre or by a coal tax upon the Rhine and Westphalian districts is unimportant, but fuel must be one of the most important considerations in the peace treaty. The destruction of equipment was thorough at Lens, Courrieres, Dourges, l'Escarpelle, and Douai. At Aniche and Anzin it was hoped, for a moment, that less destruction would be apparent, but it is just the same. Steam cylinders and air compressors were dynamited. A few cartridges carefully exploded in screen and washing plants have made them useless. Switchboards were carried away, and no trace of copper is to be found. Here and there are a few cars still loaded with coal, but most of them lie around partly destroyed by near-by explosions.

In the district of Lens the mines were flooded by turning surface water into them. In other districts only the lower levels of the mines are now flooded, owing to the cessation of pumping. By the middle of October scarcely a single inhabitant of the coal districts remained. A few miners hid themselves and stayed behind the retreating Germans, and others, escaping from the retreating enemy, are now slowly coming back to the mining districts, and civil life is beginning again.

The engineers and superintendents who had remained at the mines during the war were taken to Belgium in the retreat and are still prisoners.

A few engineers who were formerly connected with the mines are in France, and these are now returning to take such care of the property as is possible and to begin restoration.

At a few mines the destruction was not so complete as intended, and many inhabitants still remain; the Germans, with bayonets at their backs, could not always complete their tasks.

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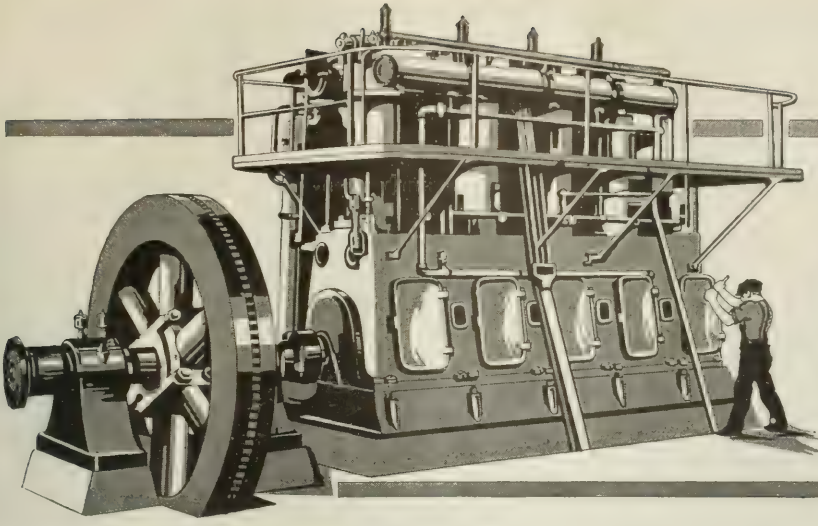
*Extract from *L'Echo des Mines et de la Metallurgie*, Nov. 3 and 10, 1918.



Talks on DIESEL Engines

by L. H. Morrison

I—The first of a series of imaginary conversations between the chief engineer of a Diesel-engine plant and his men, intended to bring out information as to the constructional features and practical operation of the Diesel engine.

IT WAS just six o'clock and the night shift had come on duty at the Diesel-engine station of the Clarksville Power and Light Co. Two 500-hp. vertical engines were working at their full capacity, and over in one end of the building the oilers were preparing a third to aid in carrying the load.

J. R. Egan, the chief of the plant—affectionately known among the men as "J. R."—got up from his desk near the end of the switchboard and stepped into the washroom, where he stood for a moment watching the day force ridding themselves of the grease and grime peculiar to their calling.

"Boys," said Egan, "I want to say a word to all of you before you leave. When you get washed up, come over to my desk." A buzz of conjecture followed the chief's retreating figure, but in a few minutes the men stood around the desk. When he had assured himself that all the force, including the night shift, had assembled, J. R. bit off the end of a particularly vile-looking cigar and addressed the men.

LIEUTENANT MORRISON

"Before I begin on my main subject," he said, "I want to explain the wherefore of my having a subject at all. Today Jim Woods here"—indicating a young fellow at the outer fringe of the crowd—"came asking for the job of oiler that we had vacant. Now, as you all know, we pay the oilers but sixty per month, and I knew Jim was running that hot-ball engine at the Acme mill and was getting seventy-five. I couldn't understand why he wanted to work for less, for Green the miller told me the other day that Woods was the best man they ever had.

"When I put the question up to Woods, he told me he wanted to get some experience with Diesel engines because he thought there was going to be a demand for good Diesel engineers. Consequently, he was willing to start in for less money.

"Now, boys," the chief continued, "Woods set me to thinking. As I look back, I can't remember that I ever tried to train any man who worked here. While I've often given suggestions, I suspect that whatever you fellows know about oil engines you have picked up yourselves. To make matters worse, I heard Kelly here tell Woods that the reason the Diesel is the most economical engine is because it burns up all the fuel. But I don't blame Kelly. It isn't often one sees any articles on Diesel-engine theory, and when you do find one, it is usually chuck-full of mathematics too deep for ordinary understanding.

"Now, my idea is this, boys. Suppose we form a class here at the plant to study the Diesel engine. We can get together two evenings a week, say from 8 to 9:30 and the night men can arrange their work so as to join us. My plan would be to take up the construction and action of the Diesel, as well as some other types. Besides, we could discuss various problems that come up in operating these engines. What do you think of the scheme?"

Kelly, the day watch engineer, was the first to reply. "J. R., I think it's a good plan. If it means giving us a chance to get more money, I'm willing to come every night. Eighty-five a month for a twelve-hour shift isn't enough money these days, and I can't see why the company don't pay us more. I'm not kicking, mind you—I'm just stating facts. Jim Woods here can live on sixty, for he's single. But what about the rest of us?"

"Boys," said the chief sternly, "if this is to be the beginning of grumbling, we'd better drop the idea. I agree that wages are too low, but it isn't the company's fault. If you go back far enough, you'll find that the real cause of low wages is the attitude of the oil-engine builders. In order to sell Diesel engines their two big claims were the small amount of fuel used and the fact that any ordinary man could run a Diesel. In fact, I heard a salesman for a prominent builder say that after the engine was started it was only necessary to lock the door to keep small boys out and the engine would continue to run as long as the fuel oil lasted."

When the laughter of the men had died down, the chief continued:

"Last year the representative of a Diesel-engine builder stated in a machinery magazine that skilled attention wasn't essential—it was only necessary for the operator to be intelligent. With such stuff being handed out, can you blame the purchaser of a Diesel engine for placing you on a par with the day laborer? That the engines do run is due to the fact that occasionally a good man is willing to work awhile at low wages. In this plant, during the last two years, more than twenty men have left—quite different from the ice plant, where the engineers and firemen have been on the job for ten years at least."

"Where does this night school help, then?" Kelly suddenly inquired.

The chief studied the end of his unlighted cigar thoughtfully before he replied.

"In this way," he said at length. "The men we usually hire are either poor help or else they get dissatisfied and quit. Now, if you men will go into the Diesel game right, it's only natural that the local manager will see that you are worth more and will come across; or else you will find some other firm willing to pay for valuable services. In either case, you win. If there was a good correspondence-school course on the subject, I'd suggest that; but under the circumstances we'll fix up a course of our own as we go along."

"I'm willing," Kelly said promptly.

"So am I," came from a number of others.

"Do you think the idea good, Woods?" asked J. R.

"That's the very thing I started working here to get," answered the newcomer.

"Very well, then; if you're all agreed, we'll begin tomorrow night, as it's Tuesday, and we'll have a session Thursday night, too."

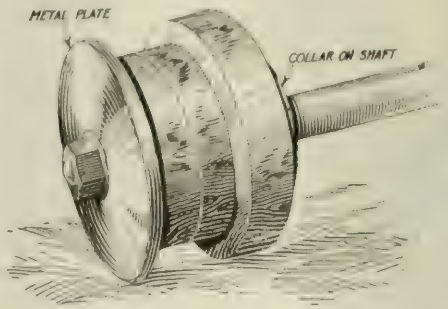
Emergency Pump Repair

An electrically driven pump was not working properly. The water in the mine at this time was already above the rails, so that the section could not be operated that day. Taking the pump apart, it was found that the metal portion of the piston had been practically eaten up by the acid of the water. A new piston and a piston rod were at once ordered. These were promised to arrive on the following Monday morning.

Monday morning came, but no piston arrived. Tuesday and Wednesday rolled around, and still no piston. All this time the water was rising. Something had to be done, or at least attempted. Accordingly, I got a piece of 2-in. oak plank and sawed out a circular section $\frac{1}{4}$ in. less in diameter than the bore of the pump cylinder, says S. D. Hainley in *Coal Age*. The edge of this was then cut away to a depth sufficient to take $\frac{5}{8}$-in. packing and for a length of 1 in. A piece of 1-in. oak board was then procured, sawed to this same diameter and attached to the piece of 2-in. plank to make the piston of the proper length.

As the available length on the piston rod was not sufficient to accommodate another 1-in. piece, a metal plate was used. This was made slightly smaller than the bore of the pump and was held in place by the regular piston-rod nut.

When this improvised piston was fitted with packing and put in place, it gave as good satisfaction as had the regular piston. In fact, it gave excellent service until the acid ate up the iron plate and permitted the packing to come off. When I asked the superintendent to have another plate made, he immediately suggested that I make a wooden one!

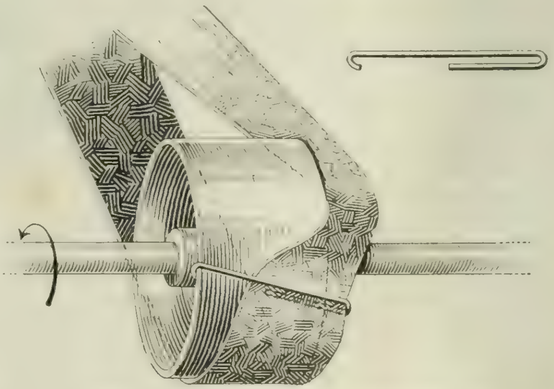


HOW PUMP REPAIR WAS MADE

Putting on Heavy Belts

The illustration shows a simple device for putting on heavy belts when it is necessary to shut down in order to do so, and where a rope is usually employed for the purpose.

Take a piece of $\frac{1}{4}$- or $\frac{5}{16}$-in. round iron and bend it, as shown in the small sketch. Hook the short end over the edge of the rim of the pulley and the long end under the belt as indicated. Start the engine slowly, and when the belt is on it is not necessary to stop, because the short end of the hook will straighten out and disengage itself. It is a good plan to use a rod of as light weight as will answer the purpose, since it will straighten out and free itself with less stress on the belt. The iron hook then falls to the floor.



METHOD OF REPLACING BELT ON PULLEY

Burning Indiana Coal on the Chain Grate

By T. A. MARSH
Chief Engineer, Green Engineering Company, East Chicago, Ind.

Characteristics of Indiana screenings from the four seams supplying most of the steaming coal. The need of large grate area, large furnace volume and strong draft to give capacity and long, high-pitched arches to improve ignition. Possibilities of improving existing furnaces.

ALTHOUGH Indiana is the fifth state in tonnage of coal produced, its fuel, until the zoning system went into effect, was not widely distributed. Recently, Indiana coal has been used in many cases where its characteristics are not understood and where the existing furnaces are unsuitable for efficient burning. Plants that have been designed for West Virginia, Kentucky or Ohio coals, usually are not suited for Indiana coal and will not give satisfactory results.

The standard coals in Indiana are found in four seams: Nos. 3, 4, 5 and 6. In addition there are produced a few special grades, but these are not classed as steaming coals and will not be considered. Steam producers are interested almost entirely in the quality of screenings, so that the conclusions following will be based on this fuel. The accompanying table gives proximate analyses, heat values and sulphur content of typical screenings from the four Indiana seams. These analyses cannot be compared on an equal basis with samples of coal as usually submitted, because such samples are based on run-of-mine or lump coal. Screenings contain usually 4 per cent. more ash than run-of-mine coal and approximately 6 per cent. more ash than lump samples. Naturally, the screenings are correspondingly lower in heat value. The characteristics of the coal from the various seams may be of interest.

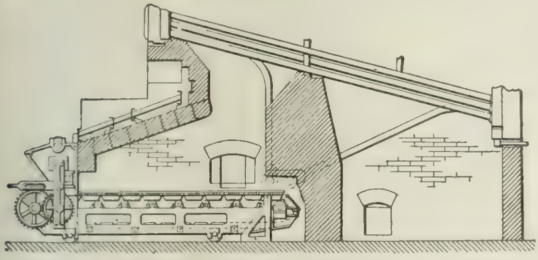


FIG. 1. TYPICAL CHAIN-GRATE SETTING UNDER VERTICALLY BAFFLED WATER-TUBE BOILER

ANALYSES OF INDIANA SCREENINGS

	No. 3 Seam	No. 4 Seam	No. 5 Seam	No. 6 Seam
Moisture	10.8	12.4	10.1	11.0
Volatile matter	35.0	33.2	33.2	31.1
Fixed carbon	36.9	44.2	42.0	41.5
Ash	17.3	10.2	14.7	16.4
B.t.u., commercial	10,400	11,069	10,820	10,540
B.t.u., dry basis	11,670	12,610	12,039	11,730
Sulphur	4.55	1.75	4.27	3.50

No. 3 coal, while not high in heat value, has the highest percentage of volatile matter and therefore gives up its heat more quickly than the others. It is an excellent coal to use to get capacity in furnaces that are deficient in ignition arches or draft, or in both of these items. The structure of the coal is soft. It therefore disintegrates readily and is not a good storage coal. Its relatively high percentage of sulphur further complicates the storage problem and the fusibility of the ash causes excessive clinker when the fuel bed is agitated. The produced tonnage of No. 3 coal is not large, and the distribution is therefore limited.

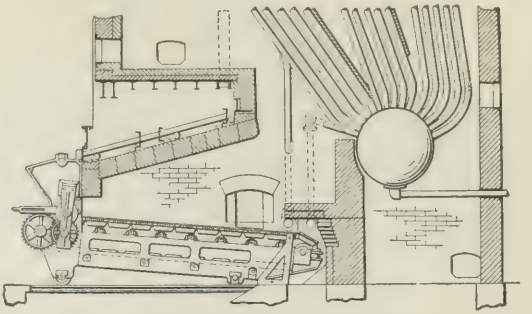


FIG. 2. MODERN FURNACE SERVING STIRLING BOILER

From the commercial standpoint No. 4 has the greatest utility of all Indiana coals. Its heat value is relatively high for a Western coal, the sulphur content is low and the coal in this seam is of uniform quality. The fixed carbon is of such good structure that when used in byproduct ovens excellent coke is produced. Owing to its uniformity and low sulphur content, No. 4 is in great demand for special process work, such as forges and heating furnaces, and commands a higher price than other Indiana coals. It is better adapted for stoker use than the other fuels mentioned, and this applies particularly to stokers that agitate the fuel bed. With fireclay above and below a large portion of this coal seam, the clinker produced is of a "pottery" brittle nature.

From the standpoint of steam production No. 5 is the most important of the Indiana coals. Its high percentage of sulphur makes it unsuitable for special process work, but on account of the large quantity produced and the assurance of supply, together with its uniformity and free-burning characteristics, it is recommended for steam-power plants. It burns more rapidly than No. 4 coal, inasmuch as the fixed carbon does not have the structure found in the latter fuel. A consider-

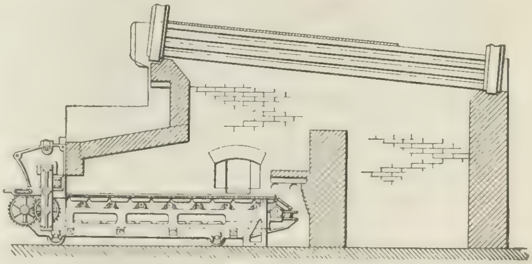


FIG. 3. CHAIN GRATE UNDER HORIZONTALLY BAFFLED BOILER

able portion of this seam has rock above and below so that there is no clay mixture to keep the clinker brittle, and although the coal is clean as regards earthy matter, the clinker produced is extremely vitreous. This coal is suitable for chain grates, but the furnace design must be such as to give good strong ignition, a point that in many instances has been overlooked.

No. 6 coal contains a higher percentage of ash than any other extensively used Indiana coal. Its moisture is slightly less than that of the No. 4, and the heat value is approximately 5 per cent. less, due to the higher ash. The ash fuses at a low temperature, making it difficult to handle. Unless the proper type of stoker is used, this coal cannot be considered, owing to the large amount of clinker produced and its vitreous structure. Use of No. 6 coal is still more limited than of No. 5, by reason of its lower heat value and the greater amount of clinker produced. It requires liberal grate areas and long arches to provide ample ignition, if good steaming capacity is to be had

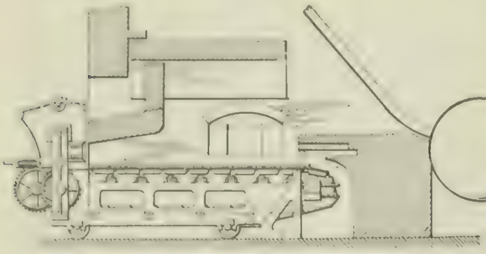


FIG. 4 FURNACE DESIGN TWELVE YEARS AGO

For the sake of economy in the purchasing of coal and in its burning, plants tributary to Indiana should be able to burn coal from the four seams mentioned and particularly from Nos. 5 and 6 seams.

The design of furnaces for these coals must be given careful thought. Many furnaces have been inadequate, mostly because of lack of knowledge of the coal and of the furnace design necessary. Large grate surfaces should be provided as these coals are relatively inert, and even with high combustion rates the capacities obtained do not correspond unless the grate areas are large. Four things must be considered in the design of furnaces for such coals as Indiana Nos. 3, 4, 5 and 6.

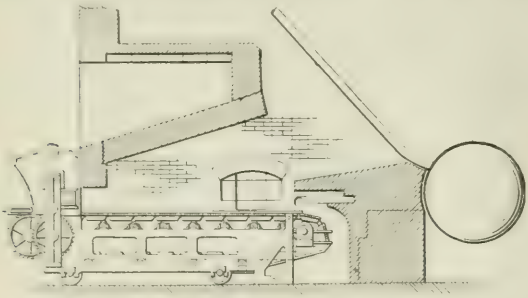


FIG. 5. REVISION OF FURNACE SHOWN IN FIG. 4

Ample draft must be provided. These coals can be burned at combustion rates of 40 to 45 lb. per sq.ft. of grate area per hour with a draft of 0.4 to 0.5 in. over the fire. Long, high-pitched igniting arches should be provided. Grate areas should be liberal with coals so low in heat value. If high capacities are to be obtained, grate areas should be provided having a ratio to the steam-making surface of 1 to 40 or even larger. Furnace volumes should be large. In furnaces where 40 lb. of coal per hour per square foot of grate area is to be burned, the furnace chamber should have a volume of 12 cu.ft. per sq.ft. of grate area, and furnaces even larger are desirable.

ADVANTAGES OF LARGE GRATES

Large grates are an advantage, as they permit high efficiencies at capacities 200 per cent. of rating and upward. A characteristic of chain grates seldom emphasized, but well known to combustion engineers, is the high efficiencies that can be obtained at ratings below normal. Many types of stoker cannot be operated appreciably below 100 per cent. of rating, owing to overheating, back draft or other difficulties. Still other types operate at low ratings but at reduced efficiencies. Chain grates reach excellent efficiencies at from 50 to 75 per cent. of rating. With inferior coals, therefore, large grates should be installed as this will insure high ratings when desired and will also give high efficiencies at lower ratings.

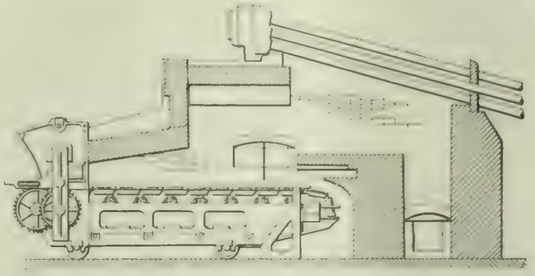


FIG. 6. OLD FURNACE EQUIPPED WITH SPRUNG ARCH

Unfortunately, many of the chain-grate installations do not have these characteristics and capacities and efficiencies are consequently limited. Modern settings, however, give combined efficiencies of from 70 to 75 per cent. when burning any one of the four coals under discussion, and develop boiler capacities 200 per cent. of rating and over. With chain grates these coals are handled indiscriminately. There is no clinker formation, as the ash forms on the lower side of the fuel bed and there is no agitation of the fuel bed. Moreover, the ash is continuously discharged from the furnace, permitting no accumulation of refuse, and air spaces are kept clean continuously by the staggered arrangement of links.

Some typical modern settings capable of producing high ratings and high efficiencies, are shown in Figs. 1, 2 and 3. Fig. 1 shows a modern chain-grate furnace under a vertically baffled water-tube boiler. Notice that the length of the arch is 75 per cent. of the length of the grate and that the grate is 11 ft. long. This may be increased to 13 ft. or even 15 ft. if the arch is lengthened correspondingly. The arch is steeply pitched and the face of the bridge-wall is built up vertically. The headroom is 12 ft. This furnace, provided with a draft of 0.5 in. over the fire, will burn 40 lb. per sq.ft. of grate area per hour of any one of the four Indiana coals. Fig. 2 shows the application of the same principles to a Stirling type of boiler and Fig. 3 to a horizontally baffled boiler.

It will be noticed that all these furnaces have large volumes. The furnace volume per square foot of grate area in Fig. 1 (allowing for a grate width approximately equal to that of the furnace) is 12 cu.ft. The furnace volume in Fig. 2 is 12 cu.ft. and in Fig. 3 is 13 cu.ft. In installations dating prior to 1916 the furnace volumes commonly found ranged approximately from 3 to 6 cu.ft. per sq.ft. of grate. The average length of arch was 4 ft. and the average draft about 0.25 in. over the fire. Even under these conditions Indiana coals were handled without clinker trouble, but in a limited manner as regards efficiency and capacity. The results from modern furnaces are far superior.

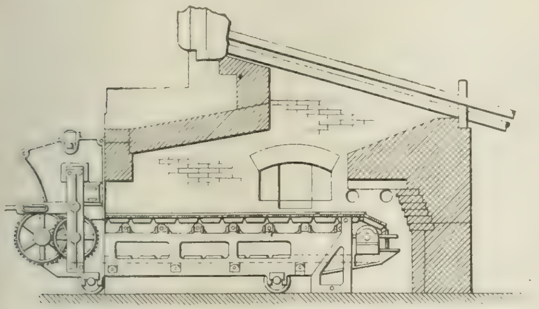


FIG. 7. REVISION OF FIG. 6, INCREASING CAPACITY AND RANGE OF COALS AVAILABLE

Fortunately, most existing furnaces permit of revision that will greatly improve capacity and efficiency. Modern arch construction can be installed. Arches can be set higher to give more furnace volume and can be made longer to improve ignition and distill off the volatile matter more rapidly. This gives better opportunity for the complete combustion of the fixed carbon. Bridge-walls can be modified to reflect the heat forward, helping the ignition, and by increasing the furnace temperature improve the combustion of the hydrocarbons.

OTHER CHANGES TO IMPROVE RESULTS

A type of arch preventing air from immediately reaching the bottom surface and chilling it should be installed. This can be accomplished by setting the front row of tile lower than the main arch surface. This construction increases the temperature at the front of the furnace. These and other modifications can be made in most furnaces, and if at the same time the boiler baffles can be rearranged to increase the draft, higher capacities and efficiencies can be obtained and the range of coals available can be widened. Many plants have already revised their furnaces with improved results. Some typical cases are shown in Figs. 4 to 7 inclusive.

Fig. 4 represents the design of a furnace installed under a Stirling type of boiler twelve years ago and Fig. 5 the recent revision of this furnace. With the original furnace only the better grades of Indiana coals could be used. In the improved setting one continuous arch, 7 ft. 6 in. long, replaces the old sprung arch. After the revision it was found that the lower grades of Indiana coals could be nicely handled, inasmuch as the draft and grate area were adequate and the ignition was better. Fig. 6 shows a furnace installed several years ago under a vertically baffled horizontal water-tube boiler and Fig. 7 the revision which materially increased the capacity and the range of coals available.

From the foregoing discussion the following conclusions are evident:

1. Indiana coals are being and will be extensively used.

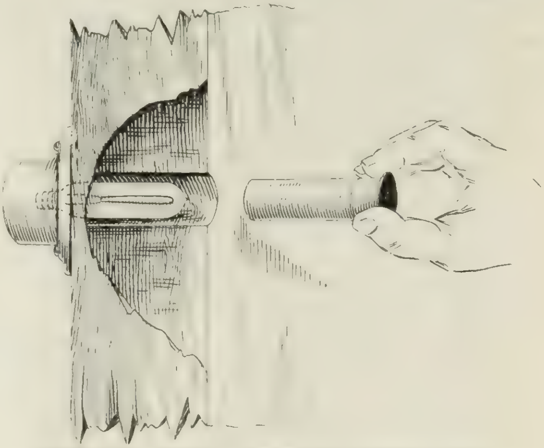
2. The characteristics of some of these coals are low fusing temperature of the ash, great tendency to clinker and large amount of clinker.

3. These coals give serious clinker trouble when the fuel bed is agitated. Continuous ash removal is preferable. With chain grates in modern furnaces, high capacities and efficiencies can be obtained from all grades of Indiana coal.

4. Existing furnaces permit improvement. Each should be considered in the light of modern engineering knowledge and can be revised, widening the range of coals to include all Indiana seams and increasing the capacity and efficiency under all conditions.

Removing Signal Lights with Shell

Tubular signal lamps as used in remote-control switchboards and similar apparatus are commonly removed, when it is necessary to replace or change them, by going in back of the board and taking off the removable socket to get at the lamp. It is sometimes difficult to locate the desired lamp from the back of the board, and frequently the back of the switchboard is not easily or safely accessible.



REMOVING SIGNAL LAMP WITH EMPTY SHELL

These indicating lamps can be far more easily removed by taking them from the front of the board with the aid of a 12-gage paper shotgun shell. The little colored glass window in front of the lamp can be easily lifted out with the fingers and an empty paper shell slipped over the lamp. The shell is of such a size that while the lamp will partly enter it, it fits tightly. It can then be easily removed by turning the shell, and a new lamp can be inserted in the same manner.

The Electrical Study Course—Parallel Operation of Generators

Discusses the object of operating several generators in parallel and the conditions which must be fulfilled by them. Shows the necessity of using an equalizing connection when dealing with compound-wound machines, and the method of its functioning.

When a constant load is to be supplied with electrical power, a single generating unit may be installed to provide the energy, its capacity being just large enough to take care of the load, since it operates at highest efficiency fully loaded. On the other hand, when the load varies greatly from one part of the day to another, it would be uneconomical to supply power from a single unit because it would be operating considerably below full load, and therefore at a low efficiency, for much of the time. Under such circumstances it is usual to provide two or more units of such capacities as will allow of their operation at as nearly full-load conditions as possible at all times.

When two or more generators are furnishing power to a load fed by them all, they are said to be operating in parallel, and the act of connecting one of them to the others is known as "paralleling" it. In order that generators of any kind shall work together satisfactorily, it is necessary that they divide the load among themselves correctly. That is, each must take its due share. The question raised is, therefore, Will any two generators operate successfully when connected in multiple? In order to answer this it is necessary to inquire into the factors controlling their behavior. For this purpose we must go back to the theory of the generator, in which it was shown that the current delivered by it is equal to the difference between the generated and terminal voltages divided by the armature resistance. That is, if I represent the armature current, E_g the generated voltage, E the terminal voltage, and R the armature resistance, we have, $I = \frac{E_g - E}{R}$, from which it is seen that E_g and R must bear certain relations to each other. If the machines are of the same size, the relation betwen the values of these quantities in each must be such that I is the same in all; if they are of different sizes, the relations must be such that I in each case is proportional to the capacity of the machine.

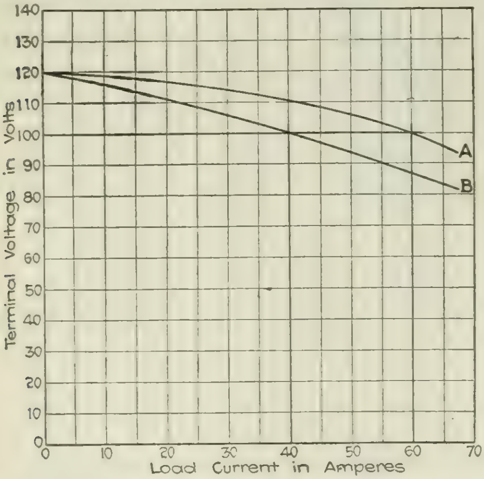


FIG. 1. DIFFERENCE IN SHAPE OF THE EXTERNAL CHARACTERISTIC CURVES OF TWO SHUNT GENERATORS OF UNLIKE DESIGN

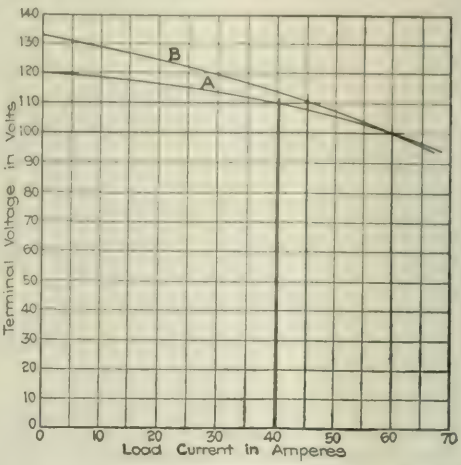


FIG. 2. EXCITATION OF GENERATOR B INCREASED TO MAKE IT TAKE SAME LOAD AS A AT 100 VOLTS

The relations existing between current, armature resistance, generated voltage and terminal voltage are governed by the characteristics of the machine. Their effect upon its behavior is most readily determined by reference to the External Characteristic Curve of the machine. This, as will be remembered, is a curve showing the relation between the current delivered by a generator and its corresponding terminal voltage. For a shunt generator its shape would be such as that of the curves shown in Fig. 1, which represent the characteristics of generators of the same size but of different designs. Although having the same voltage at no load—namely, 120 volts—they do not undergo a like decrease in voltage for similar increases in current. For example, at 100 volts the machine of curve A would be taking 60 amperes, whereas that of curve B would be taking only 40 amperes. By increasing the excitation of B or decreasing that of A, the machines could be adjusted to take the same current at 100 volts, being 60 amperes in the former case and 40 amperes in the latter. These conditions are illustrated in Figs. 2 and 3 respectively.

If these two machines were connected in parallel, they would divide the load equally when it happened to be 120 amperes in the one case or 80 amperes in the other. If they were operating under the conditions of Fig. 2 and the common load were decreased, the current delivered by each machine would decrease and consequently its terminal voltage would increase. Since the machines are connected together, their terminal voltages would be the same and we will assume that a value of 110 volts is found to exist. At this voltage machine *A* would deliver about 41 amperes, whereas *B* would deliver about 45 amperes, the total load being the sum of the two, or 86 amperes. It would require further field-rheostat adjustments to make the generators divide the new load equally between them. In like manner we will find that any other change in load will cause an unequal distribution.

On the other hand, if both machines had precisely the same characteristic, the current in each would be half the total at all times, since at the same terminal voltage the same value of current would be delivered by each. Consequently, we conclude that generators having unlike external characteristics will not operate in parallel satisfactorily and, conversely, that such as have similar characteristics will do so.

If the generators are of different capacities, their characteristics must be such that the total load will always be divided among them in the proportion of their ratings. Thus, in Fig. 4 characteristic *C* is that of a generator whose capacity is half that of the one having characteristic *D*. They both generate 120 volts at no load, as shown. A load of 30 amperes on one would reduce its terminal voltage to the same value as 60 amperes would on the other: namely, to 100 volts. At any other load the same ratio—that is, 1 to 2—would hold true, demonstrating that the machines would divide the load correctly if they were designed to develop the characteristics assumed.

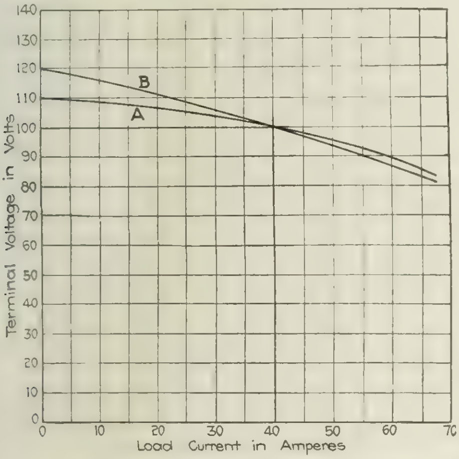


FIG. 3. EXCITATION OF GENERATOR A DECREASED TO MAKE IT TAKE SAME LOAD AS B AT 100 VOLTS

The same course of reasoning can be applied to any other type of generator, such as the series and compound. Discussion of the former may be omitted, since it finds no practical application, but the latter is of great importance. Indeed, the compound generator has a far greater variety of applications than even the shunt type; it is the most important of the direct-current machines. We shall therefore proceed to treat of the parallel operation of such machines and learn what their peculiarities may be.

The external characteristics of overcompounded generators have shapes similar to those of the curves illustrated in Fig. 5, in which *F* is the characteristic of a machine more heavily compounded than the one whose characteristic is *G*, but of the same capacity. The dissimilarity in the curves will have the same effect as in the case of shunt generators: that is, it will prevent the machines from assuming equal shares of the load. As with shunt generators, they could be made to assume the same terminal voltage for like currents by manipulation of the shunt-field rheostats, but they would not make such a division of the load of themselves. However, if possessed of identical external characteristics, they will do so, in which respect also they behave as shunt machines would. We should therefore conclude, as in the case of the shunt type, that machines with unlike characteristics will not operate well in parallel, whereas those of like characteristics will.

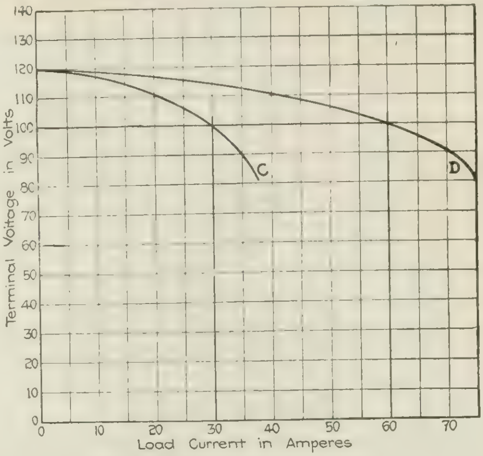


FIG. 4. EXTERNAL CHARACTERISTIC CURVES OF GENERATORS OF DIFFERENT CAPACITIES DESIGNED TO SHARE LOAD IN CORRECT RATIO

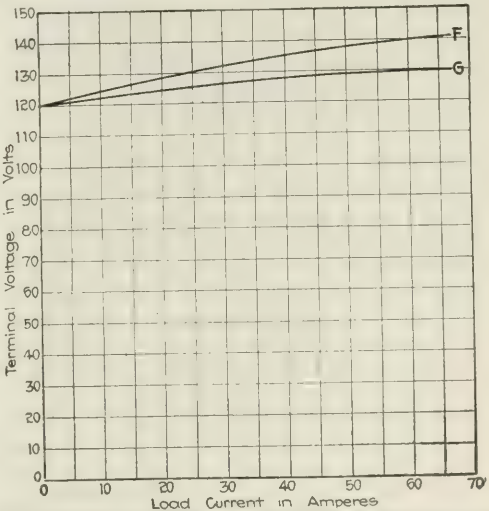


FIG. 5. EFFECT OF DIFFERENCE IN COMPOUNDING UPON THE EXTERNAL CHARACTERISTIC CURVES OF TWO COMPOUND-WOUND GENERATORS

The conclusions regarding shunt generators in parallel are borne out in practice, but it is found that compound generators refuse to operate properly even when their characteristics are identical, unless an additional feature, known as the equalizing connection—the necessity for whose introduction is not recognized as essential until a further study of conditions has been made—is provided.

In what follows an explanation will first be given as to why an equalizing connection, or equalizer, as it is frequently referred to, is required when operating compound generators in parallel, and then will follow the reason for the satsifactory operation of shunt generators without any such device. To facilitate the discussion of the points involved reference will be made to Fig. 6, which shows two compound generators, 1 and 2, connected to the mains *A* and *B*, supplying current to a load *L*. Suppose *A* to be the positive and *B* the negative; then the direction of the currents through the shunt and series fields and in the armatures will be that indicated by the arrowheads. We will further suppose that the generators are of the same capacity and design, and that they are overcompounded alike. Also that it has been possible to place them in parallel and that each is therefore delivering half the current supplied to the load *L*. The following will show that the machines cannot maintain this assumed condition.

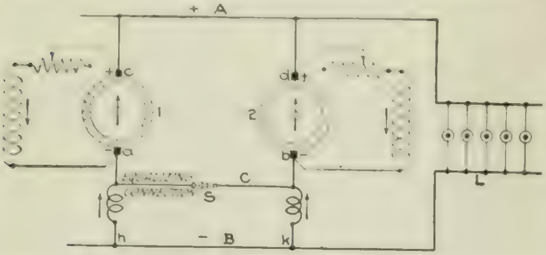


FIG. 6. METHOD OF CONNECTING COMPOUND-WOUND GENERATORS IN PARALLEL TO A LOAD

Anything affecting the generated voltage of either machine will affect its load current, since $I = \frac{E_g - E}{R}$. For example, the speed of generator 1 might increase slightly, thereby causing an increase of E_g and a consequent increase of *I*. Since the current flows through the series field of the machine, the increase in its value will cause an increase in the series-field excitation and a corresponding increase in the combined shunt- and series-field strength. The generated voltage will therefore be further increased, causing a yet greater current to flow with the effect of again increasing the field strength and in turn the current. It will be seen that the action is cumulative; that is, that, once started, it will continue unchecked. Just how far it will proceed depends upon the amount of overcompounding.

Before considering what the ultimate result would be, we will turn our attention to the other machine, No. 2, and determine what effect the action of No. 1 has upon it. When the current delivered by No. 1 increases, that of No. 2 must decrease, since the load *L* remains practically unchanged. The effect of a decrease in current of No. 2 is exactly the reverse of what an increase would have as described in the case of No. 1; that is, the initial decrease would cause a diminution of excitation which would further reduce the current delivered, again affecting the field strength, and so on until some limiting value was reached. To find what this would be, we will consider the joint action of the machines.

We have seen from the foregoing that the current delivered by one machine increases while that of the other decreases. This action will continue until No. 1 carries the entire load and No. 2 carries none. Generally, the action does not cease here, but proceeds until No. 2 is running as a motor driven by No. 1; that is, it takes current from the line instead of delivering its share to it. The direction of the current through its armature would consequently be reversed and therefore that through its series field.

The shunt-field current would, however, continue to flow in the same direction as before, since the field remains connected to the mains as before. The two fields would thus be opposed to each other, with the shunt field predominating at the time the series field begins to reverse. The total field strength will of course be less than that due to the shunt field alone, which will tend to make the machine speed up since it is running as a motor. It is, however, connected to its prime mover whose speed generally cannot be accelerated, and the motor is therefore compelled to run at the same speed as before even though its field be weaker. The counter-em.f. is therefore reduced, which increases the current, since it was found when studying motors that $I = \frac{E - E_c}{R}$, where *I* is the armature current, *E* the impressed voltage, E_c the counter-e.m.f., and *R* the armature resistance. This increase in current increases the series-field current, thereby causing a still weaker field and a consequent further increase in current. The action would continue until the current became so great that the safety devices protecting it from excessive current would operate.

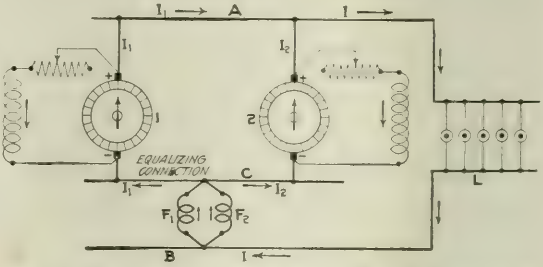


FIG. 7. MODIFICATION OF DIAGRAM FOR PARALLEL CONNECTION OF COMPOUND GENERATORS TO EXPLAIN OPERATION OF EQUALIZING CONNECTION

In practice it is found that the sequence of events enumerated in the foregoing takes place in a very short period of time; in fact, the action gives the impression of being an instantaneous one. No sooner has the incoming machine been connected to the mains than the circuit-breakers open. Often the instantaneous rush of current is so rapid that before the circuit-breakers can interrupt its flow it has become so great that its effect in flowing through the series field is to cause the series-field excitation to exceed that of the shunt field and consequently reverse the direction of the magnetic field. It would then be found that, when the machine was again started, its voltage would build up in the opposite direction to that it previously had.

Should the safety devices fail to operate before the polarity was reversed, the machine would be converted back from a motor into a generator that would be in series with the other one. The overload would be still further aggravated thereby, and only the operation of the circuit-breakers could save the machines from serious damage. In the case of generators that are only very slightly overcompounded the action would not occur with the same rapidity as in more heavily overcompounded ones; in flat-compounded, and more particularly in undercompounded and in straight shunt generators, as previously stated, there would be no such disturbances at all.

We will now go back to the subject of the equalizing connection previously referred to, show what is meant by the term, and how the connection functions in preventing the disturbances which would occur if an attempt were made to operate overcompounded generators in parallel without using it. As indicated in Fig. 6, the equalizer is a connection between the terminals *ab* of the machines. With switch *s* open they would not operate satisfactorily, but with it closed the equalizing connection would be established and the machines would then operate together successfully. The connection must always be between the junction points of the armature and series field. That is, it could not be made between *c* and *d*, for example, nor *c* and *b*, nor *a* and *d*. Moreover, it must be of a very low resistance—so low that it shall be equal to only a fraction of that of the series-field wind. Since the latter is itself small, that of the equalizer will be negligible for all ordinary values of current. In fact, the connection is usually a busbar of heavy copper similar to the other main connections to and on the switchboard. To more clearly understand the principle involved, reference will be made to Fig. 7, which duplicates the connections of Fig. 6, but shows a slightly different location of the series fields.

Suppose F_1 to be the field of machine No. 1 and F_2 that of machine No. 2, and that their resistances are R_1 and R_2 respectively. Also assume that the currents delivered by them are I_1 and I_2 and that the total current $I_1 + I_2$ is equal to I. Part of this current would have to pass through F_1 and part through F_2, the division depending on the resistances R_1 and R_2. If the generators are of like design and capacity, their field windings would have the same resistance: that is, we would have $R_1 = R_2$. Under such circumstances the current would have to divide between them equally and each would therefore carry $\frac{I}{2}$ amperes.

This would hold true irrespective of what values I_1 and I_2 might have. For example, they might be equal—let us say they have a value of 50 amperes; then the currents through F_1 and F_2 would also be 50 amperes. Again, they might have values of 30 amperes and 60 amperes respectively, which would give $I = 60 + 30 = 90$ amperes; this current would also divide between F_1 and F_2 equally, and each would be carrying $\frac{90}{2} = 45$ amperes. The point to be emphasized is that when an equalizing connection is used the currents through the series fields are not equal to the armature currents, so that a change in armature current does not affect the excitation of the generator. The equalizing connection thus insures the maintenance of the same series-field excitation in both generators under all conditions and consequently prevents the unbalancing of their loads which is otherwise found to occur.

The conditions are not changed by moving F_1 to the left of the diagram and F_2 to the right, until they occupy the positions they have in Fig. 6, since the resistance of the equalizer is very small and does not change the distribution of current. That is, there is a certain voltage drop between B and C equal to IR, where R is the combined resistance of F_1 and F_2, and since this voltage exists across both of them, the total current will always divide between them inversely as their ratio. On the other hand, if the equalizer had an appreciable resistance, there would be a drop in voltage between the junctions *ab* when current flowed through the equalizer, and consequently the voltage across *ah* would not be the same as that across *bk*, which is the case when the resistance of the equalizer is negligible.

The current through the equalizer will be equal to half the difference of the load currents. Thus, if I_e is the equalizer current, we have $I_e = \frac{I_1 - I_2}{2}$. A numerical example will show why this must be so. Suppose I_1 to be 30 amperes and I_2 to be 20 amperes. Then the current through each series field will be $\frac{I_1 + I_2}{2} = \frac{20+30}{2} = 25$ amperes, from which it will be seen that the current through armature No. 1 is 5 amperes greater than the current through its field F_1, and that the current through armature No. 2 is 5 amperes less than that through F_2. The excess current of F_2 flows through the equalizer to the junction *a* and thence through the armature of generator No. 1, thereby supplementing the current from F_1 and making up the deficiency in it. The equalizer current is seen to be one-half of the difference between the armature currents, as predicted, since we have $I_1 - I_2 = 30 - 20 = 10$ amperes, and $I_e = \frac{I_1 - I_2}{2} = \frac{10}{2} = 5$ amperes.

In the next lesson we shall inquire into the reason for the satisfactory operation of shunt generators when connected in parallel as contrasted with the behavior of compound ones when no equalizer is used. Practical points in reference to methods of connecting and operating generators for parallel service will also be discussed.

The problem given in the preceding lesson was to find the efficiency of 10-hp. 220-volt shunt motor at 25, 50, 75, 100 and 125 per cent. of full-load current. The normal current was given as 38 amperes, the armature resistance as 0.3 ohm, the field current as 1.0 ampere and the constant losses as 400 watts. Applying th

DATA DERIVED IN COMPUTING THE EFFICIENCY OF A 10-HP 220-VOLT SHUNT MOTOR

I_t	E	$I_a = I_t - I_f$	$I^2_a R_a$	$L = K + I^2_a R_a$	$W = EI_t$	$e = \frac{W-L}{W}$
Amperes	Volts	Amperes	Watts	Watts	Watts	Per Cent.
9.5	220	8.5	22	422	2,090	79.8
19.0	220	18.0	97	497	4,180	88.1
28.5	220	27.5	227	697	6,270	88.9
38.0	220	37.0	411	811	8,360	90.3
47.5	220	46.5	649	1,049	10,450	90.0

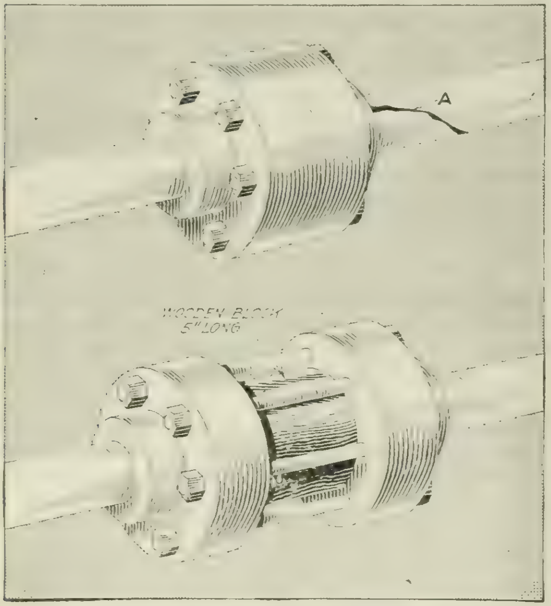
symbols used in the preceding lesson, we have the results shown in the table. The various load currents specified are represented by I_t, and the normal voltage by E. The armature currents I_a are obtained by subtracting the field current I_f, which is given as 1.0 ampere, from the values of I_t. The variable losses are equal to $I^2_aR_a$, where R_a is the armature resistance, which is given as 0.3 ohm. The total losses L are the sums of the variable losses $I^2_aR_a$ and the constant loss K, which latter is given as being 400 watts. The inputs W are obtained from the multiplication of the values of I_t by the normal voltage E. The efficiencies are then computed by dividing the inputs by the outputs, that is, dividing $W - L$ by W.

What currents would the generators whose external characteristics are represented in Fig. 1 deliver if their terminal voltage were 110 volts? What positions would the curves have to occupy if the generators were required to supply equal parts of a load of 100 amperes at 120 volts?

Emergency Shaft Repair

A shaft broke at a coupling *A*, and instead of using another coupling and a new piece of shafting, a piece 5 in. long was cut from the defective end and the new end turned on the remaining length of shafting on which to fit the coupling.

Next a round piece of tough oak wood, 5 in. long and of a diameter to fit inside of the bolt holes of the coupling was secured, as were also bolts 5 in. longer than those originally used in the coupling. All was assembled as shown in the lower view.

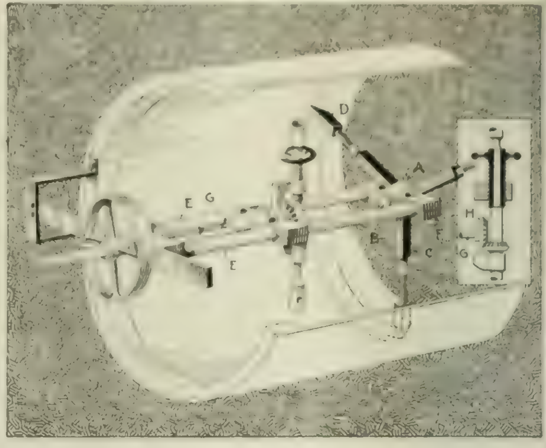


WHERE THE SHAFT CRACKED AND HOW IT WAS REPAIRED

This job was completed inside of an hour and gave satisfactory results. The wooden block held without turning, the bolts being drawn up tight.

A Special Drilling Device

The illustration shows a device that has been found of advantage when it is necessary to drill a hole from the inside of a boiler or tank, says J. A. Lucas in *Coal Age*. *A* represents a base piece made with a journal stud *B*. This base piece is provided with a radial arm *C*, with threaded ends and nuts made with conical projecting ends, as shown at *D*. One of these pieces is used at each end of the machine, when convenient, for entering and holding the frame. When not convenient to use two of them, one end of the frame is sustained as shown in the illustration or in some other manner that may suggest itself.



DETAILS OF A SPECIAL DRILLING DEVICE

The casting *F* is made of two pieces and is provided with a bearing for the pin *B* and holds the ends of the rods *EE*. The actuating shaft *G* carries the bevel gear *H*, more clearly seen in the figure at the side, which drives the drill spindle, whose ends are of different lengths for convenience in reaching to different distances. The crosshead may be slid along as required on the rods and the revolving frame and the drill turned around to different positions.

Large Pumping Stations in Holland

With a view to increasing the amount of land under cultivation, several large pumping stations for unwatering inundated, or water-logged polders, are being erected in Holland, says the *Engineer*. Another large pumping station is about to be erected at Lammerburen, in the province of Groningen, where it will be used for reclaiming the polder "Electra."

This plant will be the largest electrically driven pumping installation in Holland if not in Europe, and will comprise three screw-pumps similar to those used for the City of New Orleans, each pump being driven by a three-phase motor of 558 hp. capacity and capable of delivering 210,000 gal. per min. The three pumps together, therefore, will lift 630,000 gal. per min., or at the rate of over 900,000,000 gal. per day.

It may not be necessary for a steam-engine operator to be well versed in the theory of heat motors, but he misses a lot of solid satisfaction if he lacks that knowledge.

EDITORIALS

Morale in the Power Plant

ONE of the lessons of the war which should be carried over into the new year in power-plant practice is the value of morale. There is not much room for argument at this late day regarding the value of teamplay in industrial organizations as well as in military and naval enterprises. Morale, however, is more than coöperation; it represents the spirit of the attack upon the problem in hand or the work to be done, and is greatly needed in the reconstruction era into which the world has now entered.

The power plant is unusually well situated to take advantage of the results of morale. It is an organized affair in which orderly processes are conducted toward specific useful ends. The results attained from shift to shift or from day to day furnish an index of efficiency which should be the point of departure for the next cycle's operations. The work of the plant is closely related to industrial or other time schedules, and so the conditions are favorable for both self-discipline and high-grade executive supervision.

The successful development of morale rests upon a common objective recognized by the rank and file of the organization. While the great struggle abroad was on, this objective was the clear-cut duty of winning the war. Everything else had to be subordinated to this. Power-plant operation took on the glow of patriotic service; fuel saving became a part of the nation's tactics. Overtime was cheerfully accepted and labor shortage was acknowledged without complaint by those who filled the breach. Now the war is won and as we turn the corner of the year are motives still with us capable of leading us along the paths of efficiency, or are we going to slump back into the old days of wasting resources and being satisfied to "get by" with a certain mediocre performance in place of the superlative services rendered in the last few months and years?

The responsibility is dual. The employer, the power-plant owner, the superintendent, must see to it that a new incentive is provided and maintained for his men to "carry on," sharing in some manner the increases in efficiency secured by the staff. The old days of hiring two or three engineers and a bunch of firemen at the lowest possible wages and turning them loose in the station without subsequent regard to any ratio between pay and plant performance do not "jibe" with 1919 conceptions of justice or of good business. The days are passing when any power-plant owner has any reason to expect to "hog" all the savings made by the men who run his station; and in their place are coming days where a measure of reward for extra effort will be accorded those responsible for the improved results. And the employee—well, the time has come for him to face the everlasting fact that hard work and hard work alone must furnish the basis of all prosperity; that merely "getting by" is not the way to advance the fortunes of oneself or one's employer; and that to share in the profits one must deserve them. Thus there is a call for a new and high kind of morale, expressed in faithful industry, initiative and fair dealing for the recognition of common interests by employer and employee. With individual determination to make 1919 set a new standard in relations between plant owners and plant operators, gains in efficiency will be realized which will be mutually and nationally helpful, and something of the spirit of the fighting men of 1918 will be seen in the assault of the plant owners and workers upon preventable wastes and other evils of long standing which are now due for the discard.

Liberty Fuel

DURING the last few years the gasoline substitute, through the various nostrums that have been exploited and proclaimed by the daily press, has well earned a place beside the proverbial perpetual-motion machine. In practically all of these cases the man with the "Magic Pill" or the "Green Powder" has claimed what, to the technical man, was the impossible and thus immediately stamped the product as a fake.

These experiences have led the engineering profession to view with skepticism anything of this nature, and it has consequently received the announcement of the new Liberty fuel with the "I am from Missouri" attitude.

There is an essential difference, however, between Liberty fuel and its predecessors; the claims are more conservative and it is freely admitted that the basis of the fuel is kerosene—as high as eighty per cent—the remaining ingredients, which have not been officially disclosed, imparting the necessary "pep" to the kerosene.

The new fuel appears to have been evolved with a view to meeting the predicted shortage of gasoline during the spring of 1919 had the demands of the war continued. Its performance does not differ greatly from that of gasoline and the cost, it is claimed by the inventors, would be slightly less. The tests made at the Bureau of Standards, reproduced in part elsewhere in this issue, do not show marked advantage over a high grade of gasoline, the essential difference being a greater initial explosive effect with resultant higher flame propagation and lower temperature of exhaust gases—an advantage, as concerns a cooler-running engine, provided there are no accompanying detrimental effects.

For reasons involving the rights of the inventors they have not seen fit to disclose the composition of the mixture or the process, but indications point very strongly to the employment of a well-known explosive in small quantity as one of the ingredients. Whether this is in sufficient quantity to produce a detrimental effect on the metal of the engine by long use under service conditions remains to be proved. It is too early to condemn the fuel, and out of fairness to the inventors, opinion should be reserved. On the other hand, the sooner they come out into the open the sooner will confidence in the product be established. It is significant, however, that, although the tests were conducted at the Bureau of Standards, that Government agency has not yet seen fit officially to give its stamp of approval and the proposition in many respects remains a private one.

"La Ingenieria Internacional"

REALIZING the value of the international exchange of ideas on things engineering, the McGraw-Hill Company on March first will begin publication of a magazine dedicated to that purpose. While eventually it is expected to appear in editions in several languages, the original issue will be in Spanish, under the name, "*La Ingenieria Internacional*," aimed to serve Latin-America and Spain.

The purpose of the new magazine, which has been under consideration for several years, is to afford a medium for the presentation of those developments in American engineering which may be of value to engineers, contractors and manufacturers in other lands. At the same time, following the practice of the present McGraw-Hill publications, a far-flung editorial organization will be developed, so that there will be drawn into the paper the best of engineering practice in Latin-America, Spain and other Spanish-speaking countries. Aside from this function, the new magazine will be an important developer of international good-will, and at the same time a medium by which American manufacturers engaging in export trades can carry their message to prospective buyers in foreign lands. It may be a cause of surprise that the McGraw-Hill Company, whose specialized papers circulate so widely overseas, should establish a magazine to serve the foreign field. The reason, however, is not hard to find. The present highly specialized papers appeal only to those who are situated where engineering enterprise has made such progress that there is room for the specialist and need for the latest refinement in equipment and design. But everywhere the world over are territories newly developing where the engineer, the contractor and the manufacturer must turn their hands to many lines. It is to serve the general practitioner so situated that the new magazine, and its later companions in other languages, will be started. The specialized papers in English will still hold their place as the recorders of the best in the advanced practice of American engineering.

Pointers on the Care of Equipment

THE letter on another page of this issue, describing the difficulties the contributor at first experienced in operating an indirect automatically controlled heating system is proof, if proof be needed, of the soundness of the stand *Power* has always taken—that it is to the mutual advantage of both manufacturer and user to publish complete and intimate description of all equipment and full instructions for its care and management, together with suggestions as to things to "watch out for."

It can be acknowledged by anyone that his apparatus is not foolproof without detracting in the least from its merit. A thermostat, for example, is a delicate instrument, and it is often mistreated or neglected simply because the man in charge of it does not realize its delicacy. An exceedingly small air leak or particle of scale may cause it to fail to function properly. Why not caution the engineer against such things? The user of an electric motor may get along first rate without knowing the kind of winding on the armature, but knowing its construction thoroughly, he will no doubt take more interest in his machine.

It is safe to say that many good systems of heat control have failed and become discredited simply because there was little or nothing done by the manufacturer or dealer to "wise up" the user of the equipment. *Power* stands ready to entertain such articles for the benefit of all.

A Series of Articles on the Diesel Engine

CONSIDERABLE impetus has been given to the Diesel-engine industry in the United States by the adoption of Diesel engines for the propulsion of a large number of ocean-going vessels of various types built during the war. The same type of engine has also been installed on many vessels as a source of power for driving lighting outfits to be used in emergencies. The result has been to focus attention on the Diesel engine as a prime mover.

In this issue is the first of a series of twenty articles dealing with the details of construction and operation of stationary Diesel engines. They are written in the form of informal talks between the chief engineer of a Diesel-engine plant and his associates, and so they naturally lead to friendly discussion of the troubles met with in the management of the engines and the methods used to overcome the difficulties.

Lieutenant Morrison, author of the articles, has had an extensive and varied experience in erecting and operating oil engines, particularly in the Southwest, and so he writes from first-hand knowledge of the subject. Regular readers of *Power* will recall his recent series of contributions on the low-compression oil engine. The new series is equally informative and will be of value to all who are interested in the Diesel engine.

Failure has brought success in many instances. The Allied army failed to decisively defeat the German army for over three years, but where is the German army today? Westinghouse could not find a market for his air-brake when it was first perfected, but look at it now. The Panama Canal was a failure under several managements, but Uncle Sam finished the job. Moral: If one effort is a failure, it does not mean that the situation is hopeless. Tackle it again!

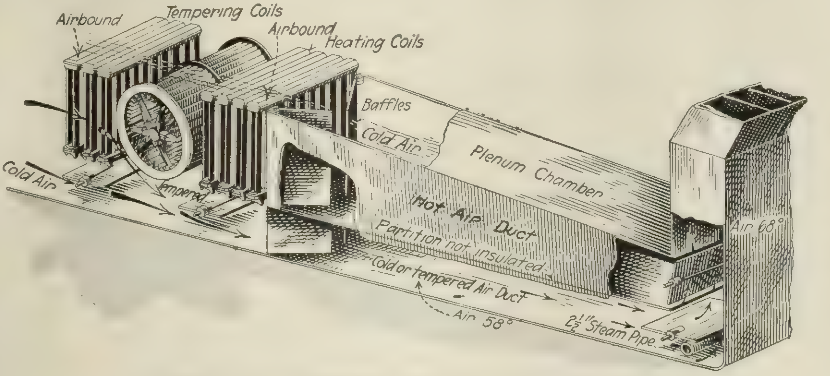
Since the Fuel Administration became active in its investigation of steam plants, many an engineer has discovered that daily plant records are just as interesting as box scores and batting averages, and considerably more important.

CORRESPONDENCE

Experience With Automatic Indirect Heating System

Following is the story of some of the troubles we had with an automatically controlled indirect heating system in a public school. Being unfamiliar with this particular system of control at the time, I called on a representative of the company and was given many good pointers and among other things was told that every system, even of the same make, has its own peculiarities of operation. That this is true I found out before the heating season had progressed very far.

The first "snag" that we struck was that we could not heat the whole building at once. One half would not heat until the other half was up to temperature and the thermostats had closed half the dampers in the plenum chamber; in fact, one half of the building would actually get colder while the other part was being heated. As the time for heating the rooms was unreasonably lengthened by this, I began to hunt high and low for the trouble, and I found that, on very cold days especially, the heating coils would heat only halfway across. Raising the pressure to 15 or 20 lb. did no good. The steam supply was of ample capacity and the manifolds, top and bottom, were large, but the air vents or valves were located on the wrong side of the radiators, allowing them to become airbound, and of course the air passing at that side was not heated. We could not change the location of the valves during the heating season, but improved the operation greatly by installing baffles in the plenum and tempered-air chambers in such a way as to mix the air to a uniform temperature, after which we had no trouble in raising the temperature evenly throughout the building. We will have the vents changed in the spring.



GENERAL ARRANGEMENT OF COILS, FAN AND DUCTS

In mild weather the building was overheated because the thermostat in the tempered-air chamber was located about midway of the length of the tempered-air duct instead of at the extreme end, so we had to keep the thermostat set for a low temperature (58 deg.) at this point because the temperature was increased another 10 deg. in passing to the end of the duct, partly because of the partition between the two chambers, the tempered-air and hot-air duct not being insulated. An uncovered 2½-in. live steam pipe in the tempered-air duct also tended to raise the temperature still more. To "get next" to such peculiarities takes time, and in the interval someone has to suffer inconvenience. In many instances a perfectly good system of heat control is condemned because of defective installation and improper operation of the apparatus.

A. Blom.

Charleston, Ill.

Making Diesel Operators from Steam Engineers

On page 816 of the issue of Dec. 3, 1918, I notice an editorial on "Making Diesel Operators from Steam Engineers." This article was written on suspicion, apparently, and it might have been a good thing to have had the suspicion verified first. In regard to the difficulties of operation I would like to call to your attention the fact that the cylinders in a Ford automobile have very much nearer the temperature and pressure conditions in a Diesel engine than they have to those obtaining in an ordinary, reciprocating steam engine. Have you ever heard it asserted that a Ford automobile needed an extraordinarily skilled attendant, due to these pressures and temperatures? I never have, and I don't believe anyone else has. As for the running clearance of the pistons in the liners, Diesel engines have two or three times the clearance that a good many of our steam engines had.

The ideal engineer to have charge of a Diesel-engine installation is one that is a good executive to see that his force is properly organized and that the various things that have to be done are actually done from time to time.

This, you will notice, is the same kind of man who should have charge of any machinery. The Diesel engine and the things that have to be done can easily be understood and learned by any operator of intelligence. Special skill is not required, and if he will see that these things are done from time to time he is no more likely to have trouble with a Diesel engine than with any other kind of engine. In fact, the things to do to operate a Diesel engine properly call for less skill and are much easier to learn than the things necessary

to properly operate a steam plant. We have become so familiar with the steam plant, however, that the skill necessary for its proper operation is taken as a matter of course.
HARTE COOKE,
Auburn, N. Y. McIntosh & Seymour Corporation.

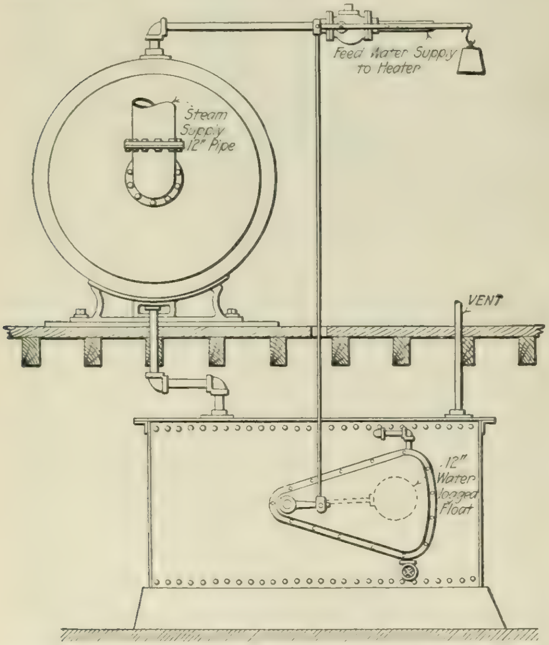
Speculation Regarding a Boiler Explosion

In the issue of Nov. 26, 1918, page 776, there appears an account of a boiler explosion, accompanied by a chart from a recording gage, upon which I wish to comment. There was a sharp rise in pressure from 6 to 6:20 a.m. due to the breaking up of the banked fire. At this time it was doubtless discovered that the water was low, and starting the pump and closing the draft caused a decided drop—to about 40 lb. Then it was decided to pull the fire, the steam holding up well during this period, but it afterward went down very rapidly to about 5 lb. At this time the water coming in contact with the hot plates turned it into a flash boiler, causing the pressure to rise so rapidly as to show instantaneous rise on the chart to 120 lb. at 10 minutes to 8 o'clock, at which time the explosion took place. It is well known that a high pressure can be obtained in a few minutes with flash boilers. This makes them dangerous and prevents them from coming into general use.

Spokane, Wash. WILLIS W. NELSON.

Floatless Floats

A 12-in. copper float, connected to a valve in the water-supply pipe to our open feed-water heater, filled with water, sank to the bottom and remained there, "dead." Acting on the well-established principle that it is a bad habit to spend money, the chief refused to order a new one. A lever, with a counterweight, was bolted to the valve arm, which raised the float to the surface of the water, converting a buoyant float into a simple displacement body. A buoyant float exerts force to rise to the surface, while a displacement body exerts its greatest force in an opposite direction when not in water, because of its weight. I think this type of float can be used to advantage in many places and do away with the annoyance that is almost sure to occur sooner or later with any buoyant float. The illustration only suggests how to apply this principle in a simple and practical way.

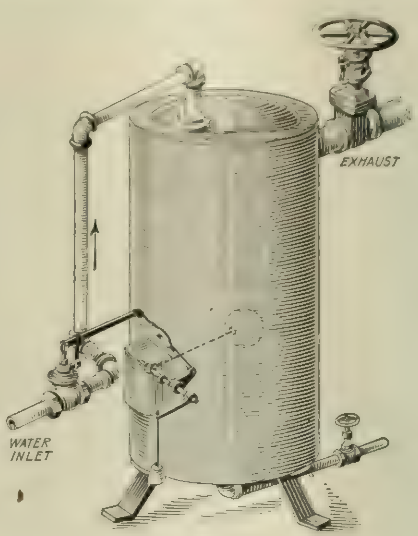


COUNTERWEIGHT BALANCES FLOAT WHEN IN WATER

In our case this arrangement is now working nicely, is positive in action and is certainly troubleproof.

Milford, N. J. GEORGE WOOLAVER.

For some time the float in our heater had a leak, and it would not rise and shut off the water. The heater would fill until the water ran out at the overflow and sometimes if the load was light the water would get into the exhaust pipe. What we need, of course, is a new float, but that costs money and it is quite a job to take the heater apart. To tide over, I made a clamp and fastened it to the rod that the float is connected to and hung weights on the end of the clamp, acting in the opposite direction, to balance the extra weight of the float. The float is now held partly out of the water, and as the water recedes the weight of the float overbalances the outside weight, closing the valve, and the water is held at the right height in the heater.



LOGGED FLOAT HELD UP BY OUTSIDE WEIGHT

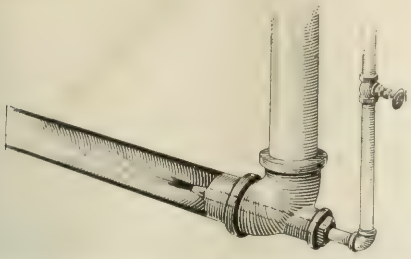
JOHN W. WARWICK.
Salt Lake City, Utah.

[By a curious coincidence the foregoing two letters on the same subject reached us at almost the same time.—Editor.]

Utilizing Waste Exhaust Steam

We have two separate heating systems in which exhaust steam is used. Into one of them more exhaust is discharged than can be utilized, and some of it was formerly allowed to escape to the atmosphere; but into he other there is not enough discharged to supply the demand, so that live steam at low pressure had to be admitted through a reducing valve.

I have connected these systems and steam flows from one to the other. To overcome the friction in the pipe and increase the flow of steam a "siphon" was added.



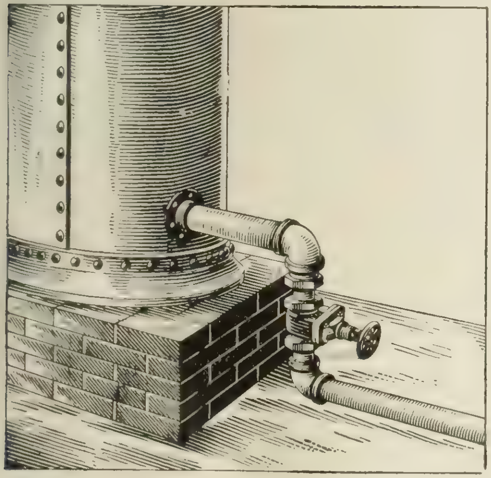
HIGH-PRESSURE JET IN HEATING SYSTEM

This draws steam from one system and discharges it nto the other, giving satisfactory results. The high-pressure steam pipe is only ⅜-in. with a ⅛-in. nozzle, hence it cannot use as much high-pressure (75-lb.) steam, and since it is discharged into the heating system it is not wasted. W. H. **Wakeman.**

New Haven, Conn.

A Dangerous Blowoff Connection

A large vertical boiler was installed with the blowoff piping made up as shown in the illustration. The opening in the shell was for 2½-in. pipe, and on the end of the first nipple used was a regular 2½-in. elbow with a 2½ x 2-in. bushing in its lower end. Then followed a 2-in. nipple and one of the poorest gate valves on the market. This valve might have lasted a few months, but the light cast-iron bushing was the weakest point in the line, as it reduced but one pipe size and was plainly too weak to be used in connection with 150 lb. pressure. Furthermore, it was not screwed into the elbow enough to take up all the threads.



BUSHING USED TO MAKE UP BLOWOFF PIPING

When the boiler inspector made his first visit, this piping was condemned and taken out, thus preventing what would probably be called an "accident" in case of a failure. The specifications and the blueprint for this piping called for a reducing elbow, thus dispensing with a bushing at this point. Notwithstanding this, the job was done as shown. W. W. **Henry.**

New Haven, Conn.

Boiler Blowoff Valves

The letters about blowoff valves are getting interesting and demonstrate that too much care cannot be used in dealing with this part of the boiler equipment.

A regular overhauling or inspection of the blowoff valves at least once a month should inform one of the condition of the valves, and it would be impossible for the bolts to rust through between inspections, even though they are subject to salt water, dampness from blowing back of exhaust steam, leaky tubes, and soot or flue ashes from cleaning the boilers, and combustion chambers. The type of fittings also plays an important part. Some use screwed valves and fittings rather than flanged ones because they are a little cheaper, but this is bad practice. The space in back of boilers is usually limited and crowded with connections, besides being dirty and wet while cleaning the boilers, especially those of the water-tube type. The blowoff must be connected to the lowest part of the boiler and is therefore usually close to the floor. Under these conditions a man grinding or repairing the valve will seldom do the best work. He is anxious to get the job done as soon as possible, but if flanged valves or stop-cocks are used they may be taken out in a few minutes and the grinding and repairs attended to on a bench where it can be well done and the valves examined both inside and outside.

These two points, frequent examination and the use of flanged fittings, will prevent a great deal of trouble and give men confidence in the safety of the blowoff piping. I agree that a stop-cock having the plug held in place by a substantial gland or guard is the only kind that is safe. F. C. **Heylman.**

Martinez, Calif.

In various issues of *Power* I have noticed that when a blowoff cock is illustrated, the old style, open top and bottom, is invariably shown. Inasmuch as this type is practically obsolete and in fact its use prohibited by law in some states, it seems that an up-to-date type should be shown instead. L. C. **Coombs.**

Louisville, Ky.

Unsymmetrical Indicator Diagrams

Commenting on "Unsymmetrical Indicator Diagrams," by J. Lewis in the issue of Dec. 10, page 856, I do not understand how he could increase the compression effect by increasing the compression on two ends of the two cylinders by robbing the opposite two ends. With the compression about equally divided between both ends of each cylinder, the compression presure per square inch of piston area would be as great as the pressure indicated by the diagram, and would be much better steam distribution.

By observation (that is, without measuring) the areas of the crank and head ends of both diagrams appear to be about equal. This being the case, if the valves were moved so as to cause about equal compression on both ends of the cylinders, the points of admission and cutoff would be greatly changed, increasing the area of one end of the diagram over the other. [The diagrams shown were simply to illustrate the point.—Editor.]

I gather from the letter that the engine had a piston or Sweet, or similar type of valve. Therefore, to increase the compression either an offset shaft key in the governor wheel, so as to advance the governor wheel, or an offset (that is, eccentric) governor rod pin should be installed in the governor instead of the concentric pin. This would advance the valve travel in relation to the crank, giving an earlier steam admission, which would help out on the compression. It would also diminish the maximum cutoff of the steam admission, but not enough to prevent the engine from carrying a good overload if the diagrams as shown were taken at about full or average load.

Two wrongs in this case do not make one right.

San Francisco, Calif. V. R. HUGHES.

Combating Boiler-Tube Failures

The following is an account of the method used in combating the tube failure in 14 water-tube boilers totaling 6200 hp., the trouble being due to scale. The operation and maintenance of the boiler plant rested upon a foreman. As the job had frequently changed hands, no boiler-maintenance records of any value were available, but as the output of the plant increased and the shortage of labor became more acute daily, the present foreman found himself up against it.

Instead of starting at the end of the boiler house and going down the line, cleaning each boiler completely regardless of the actual hours it had been in service, a record was kept of the time each unit was in operation and the one showing the most hours was cleaned first. This did not help matters to any great extent, but it did show that when a boiler had reached 600 hours of service without being cleaned, tube trouble could be expected, which was taken care of as follows:

After about 500 hours of service, six rows of tubes only were turbined each time—the two bottom rows and four others. For instance, at the end of one period the two bottom rows and the third, fourth, fifth and sixth from the bottom would be cleaned and at the end of the next period, the two bottom rows and the seventh, eighth, ninth and tenth rows from the bottom. This method helped considerably, and where formerly the replacement of one tube a day was getting to be the rule, we now renew about one a month.

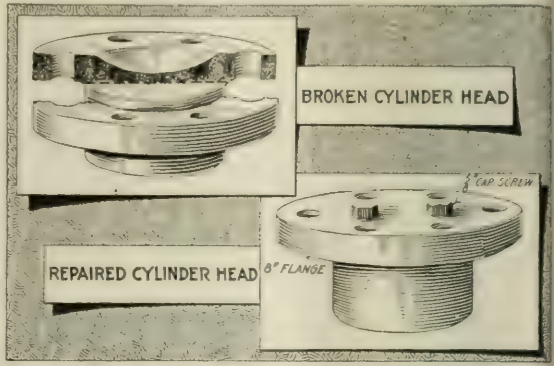
With the aid of a draft gage, Orsat and steam-flow meter furnace-cleaning periods were also established, as were periods for cleaning the waterbacks, etc. These latter periods were more flexible and were stretched or shortened occasionally to fall in with a cleaning period and thereby eliminate needless shutting down of a boiler.

I might mention a few other arrangements that helped a great deal, such as the use of a turbine tube cleaner that left a clear tube before it would pass through; rigging up the hose so that one man could handle a cleaner; using a slice bar with a wide blade and keeping it sharp; and last but not least using the Orsat, draft gage and flow meter to determine as far as possible the best firing conditions and instructing the fireman accordingly, also staying with him enough to see that he did his work. A. ENGELLAND.

Joliet, Ill.

Broken Cylinder Head Repair

The head blew out of a 5 x 5-in. steam cylinder operating a stoker, at about 1 o'clock p.m. and as the stoker was needed for the evening load coming on about 4:30, I made a temporary repair as follows: I chipped the broken head along the line shown dotted, keeping depth measurement as near as possible to that of the original head, and secured this hub part to an 8-in. blank flange, which happened to be the right size, with two ⅝-in. capscrews, as shown in the illustration. The job took three hours and the stoker was ready in time.



BLANK FLANGE IN PLACE OF CYLINDER HEAD

Trenton, N. J. JOHN T. LOCKETT.

Valves Do Not Wear Well

A pump handling the returns from a vacuum heating system was fitted with old hard-rubber valves that were in bad condition, being tapered at the edges. As new ones had not arrived at the beginning of the heating season, the old ones were dressed down by using sandpaper and then they were ground to a fit on the valve seats, using common grinding compound. The result was pleasing, but as the material was too brittle, soft valves were used, which give better results while they last, but are not expected to last as long as hard rubber valves, which in my case is about two weeks.

The returns vary from 60 to about 180 deg. F., and with these temperatures hard-rubber valves break where the studs come in contact with them; in some instances they break in small pieces. Some of the valves have holes on the lower side that resemble burst blisters, but there are none on the upper side.

It appears from the foregoing that something is wrong with the kind of valve used. Who can suggest a remedy for the short life of these valves? M. C. LARSEN.

Omaha, Neb.

Development of the coal resources of Alaska, which has been reported as locked up by Federal laws, has been greater in 1918 than in all previous years. Alaska anthracite is now being sold in Seattle.

INQUIRIES OF GENERAL INTEREST

Safety Valve for Double-Grate Down-Draft Boiler—In selecting the size of a safety valve in accordance with the size of grate, how should the grate area be estimated for a double-grate down-draft boiler? B. R.

Where a boiler is provided with a double grate for down-draft combustion, the grate area taken for estimating the size of safety valve should be the area of the lower grate plus one-quarter of the area of the upper grate.

Pitch of Rivets of Girth Seams—Why is the pitch of rivets on girth seams of horizontal return-tubular boilers generally made less than in the longitudinal seams? W. P.

The outer plate in a girth seam is more or less overheated where the seam passes over the fire, and there is a tendency for the outer plate to expand away from the inner one, resulting in leakage. For this reason the space between rivets is made smaller than on cool seams of the boiler.

Heat of Combustion of Various Fuels—What quantity of heat is developed by combustion of fuel oil, coal, natural gas, carbon, hydrogen and acetylene gas? N. C. D.

The heat of combustion of fuel oil, coal and natural gas depends on their analyses. The heat of combustion of fuel oils varies from 18,000 to 20,000 B.t.u. per lb.; commercial coal from 10,000 to 14,000 B.t.u. per lb.; natural gas about 1000 B.t.u. per cu.ft. The heat of perfect combustion of pure carbon is about 14,500 B.t.u. per lb.; perfect combustion of hydrogen in air 50,000 to 60,000 B.t.u. per lb. and acetylene in perfect combustion, with oxygen, 1685 B.t.u. per cubic foot.

Improving Flexibility of Leather Belting—What is the best method of improving the flexibility of a new leather belt; is not mineral oil good for the purpose? W. K. S.

Mineral oil is a solvent of albuminous substances and therefore is detrimental to the natural cementing substance of leather. For improvement of the flexibility, remove the glaze from both sides of the belt with a damp cloth and give both sides a liberal coat of lukewarm neatsfoot oil, rubbed off dry after standing 10 to 12 hours. A new leather belt should be thus treated several times a month and afterward kept moderately "stuffed" with the oil to prevent stretching and cracking from alternate absorption of moisture and drying out with changing conditions of the atmosphere.

Obtaining Additional Compression on Corliss Engine—On a Corliss engine with two eccentrics, should increase of compression be obtained by changing the length of the exhaust-valve rods or by advancing the exhaust eccentric? W. K. R.

It is better to obtain additional compression by advancing the exhaust eccentric rather than undertake to preserve pressure of expansion near the end of the stroke where it is of little value. If the cutoff is short, earlier release may be of benefit in preventing the valves from slamming on account of the pressure being carried below the back pressure, while with a heavy load it always is desirable to have release early enough for the cylinder to be cleared of steam previous to the return stroke.

Form of Chimney Flues—Why are smoke-stacks made larger at the bottom than at the top? E. E. R.

Brick chimneys and self-sustaining steel stacks are generally made larger at the bottom to increase their stability against wind pressure and sometimes only for architectural effect. On account of loss of temperature of the gases in their ascent through a chimney flue, they are somewhat denser at the top of the chimney, and enlargement of the flue at the bottom may have some advantage in obtaining greater uniformity of velocity of the gases. But for chimney flues of ordinary proportions, such an advantage is negligible and the draft capacity may be considered as equivalent to that of a flue of uniform size and of cross-section equal to the smallest part.

Relations of Currents in A. C. Systems—For transmitting a like amount of power at the same voltage and power factor, what would be the value of the current in each of the following systems: (a) single-phase, (b) four-wire two-phase, (c) three-wire two-phase, (d) three-wire three-phase, and (e) four-wire three-phase? W. D. T.

If I is the current in amperes, W the power in watts, E the voltage, and $P.F.$ the power factor, we would have (a) $I_a = \frac{W}{E \times P.F.}$; (b) $I_b = \frac{I_a}{2}$; (c) in the two outside wires $I_c = I_b$ and in the common wire $I_c = \sqrt{2}\, I_b$; (d) $I_d = \frac{I_a}{\sqrt{3}}$; and (e) in the three outside wires $I_e = \frac{I_a}{\sqrt{3}}$; and in the common wire $I_c = 0$. The foregoing conditions are true on the assumption that load is evenly balanced between the phases.

Advantage of Inclined over Vertical Belt Drives—Why will a belt on an angle of about 45 deg. transmit more power than a vertical drive? F. A. S.

When a belt is placed over a pair of pulleys, both sides of the belt may be assumed to have the same tension, but while transmitting power the belt stretches from greater tension on the driving or tight side, which immediately results in less tension on the slack side. When the sides are vertical, as in Fig. 1, the slackening may be sufficient to permit the belt to fall away from the lower pulley as indicated by the dotted line, or at least reduce the pressure and friction between the belt and the face of the lower pulley and this condition is aggravated by the weight of the belt. When the belt is inclined as shown in Fig. 2, increase of tension on the driving side reduces the tension on the slack side. When the lower side *AB* is the driving or tight side, the slack side, indicated by the dotted line *CDE*, becomes wrapped around more of the lower pulley; and when the upper side *CE* is the tight side, the slack side assumes a position like *AFB* and remains wrapped around nearly as much of the lower pulley. In either case the belt remains supported by the lower pulley and there is assistance of the weight of the belt to produce pressure against the face of the lower pulley. Hence for the same initial tension a belt is capable of transmitting more power than when the drive is vertical.

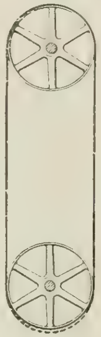


FIG. 1

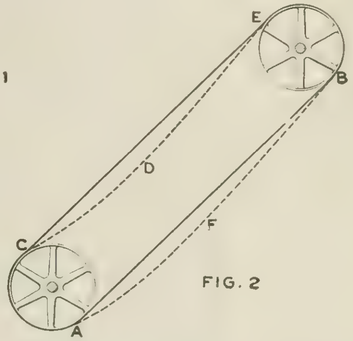


FIG. 2

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary for the inquiries to receive attention.—Editor.]

The Chemical and Physical Control of Boiler Operation*

By E. A. UEHLING

The economical status of a boiler plant can be approximately determined by either the mechanical method, based on the heat utilized, or the chemical and physical method, based on the heat wasted. The author discusses the advantages and disadvantages of both methods and shows that while each is necessary for complete results, the chemical and physical method gives more directly useful information.

THE value of a fuel depends on the heat it contains, and the value of the heat depends on the degree of its utilization. The heat contained in coal is liberated by the chemical process of combustion, hence combustion efficiency is the prime requisite for the economic utilization of fuel. This is especially true in the application of heat to the steam boiler. The economical status of a boiler plant can be ascertained, in a rough, wholesale way, by either of two distinct methods: The mechanical method, based on the heat utilized; or the chemical and physical method, based on the heat wasted. The mechanical method relies on the readings of the coal weigher and the water meter or steam-flow meter. If the heat value of the fuel is known, the data obtained by these appurtenances enable one to calculate roughly what percentage of the heat in the coal is utilized in making steam. For obvious reasons the results cannot be calculated oftener than once a day, and generally once a week is considered sufficient for a control over the operation of the boiler plant. Aside from the lateness in getting the desired information, this method suffers in accuracy and reliability as a control from the following errors and shortcomings: The coal weigher cannot discriminate between coal and ash and moisture, and since these constituents are never constant and frequently vary 5 per cent. or more in successive shipments, and since the heat value of the fuel depends on its purity, the calculated results will be that much in error; the water passed through the meter is not all evaporated, an appreciable amount may be carried over with the steam, more may be lost through leaky blowoff cocks, and considerable is wasted by blowing off the boilers, which is not only not accounted for but actually appears on the credit side; the steam may be superheated; the feed-water temperature may vary appreciably. Thus we see that a water meter and coal weigher can give only a rough, wholesale control, unless supplemented by scientific instruments and observations. The mechanical control has another and even more serious shortcoming in that it gives absolutely no clue as to why the plant as a whole is operating more or less wastefully.

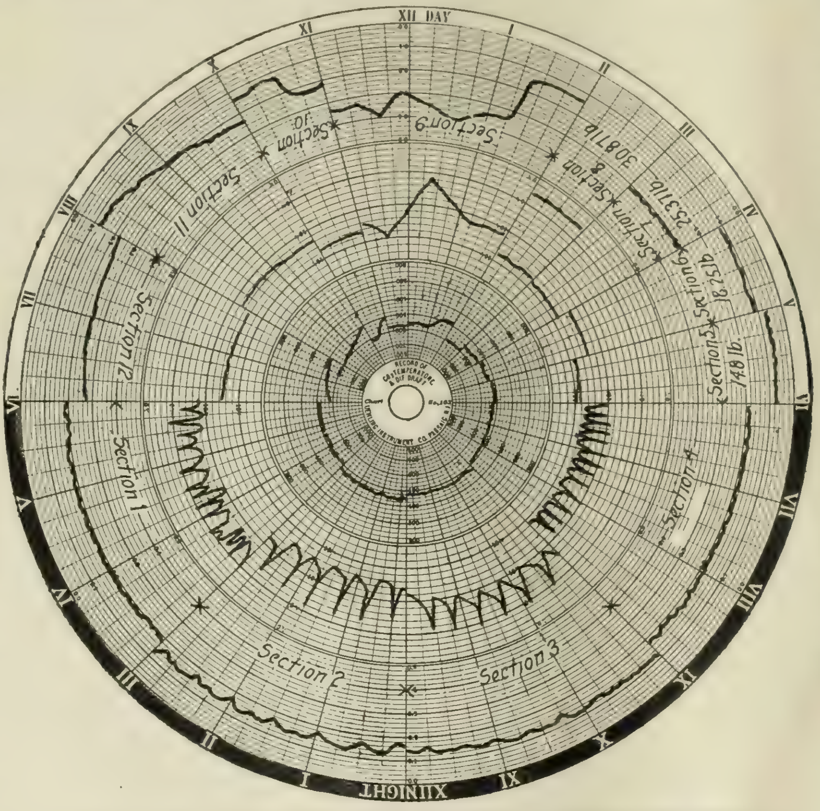


FIG. 1. CHART FROM INSTRUMENT RECORDING SIMULTANEOUSLY PERCENTAGE O CO$_2$, STACK TEMPERATURE AND BOILER DRAFT UNDER VARIOUS CONDITIONS

The wholesale chemical and physical method of control is based on the readings of a CO$_2$ meter and pyrometer inserted in the main gas flue at or near the chimney. The chemical and physical method suffers from the following deficiencies and inaccuracies: The indicated and calculated results are qualitative; the results do not represent all the heat wasted; from the CO$_2$ determination in the chimney one is unable to discriminate between excess air through the fire and that leaking through boiler walls, as well as that leaking into the gas flue between the boilers and the point where the sampling tube must be inserted to get the gas from all the boilers. Air entering beyond the boilers does not militate against efficiency except as it may overburden the chimney and reduce the draft below that required for efficient combustion.

The wholesale chemical and physical method has the following advantages over the mechanical method: It can be more easily and cheaply installed; the records show up the collective operation of the boilers continuously instead of only at the end of longer or shorter periods—one day at best; it shows up the combustion and absorption efficiency factors separately so that the proper steps to improve the efficiency of the plant can be promptly and intelligently taken; the value of its records is not affected by a vibration in ash or moisture content of coal burned, nor is the record affected by the waste of feed water or the variation in its temperature.

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*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, December, 1918.

Both wholesale methods are equally handicapped as an aid to improve boiler efficiency, because, before one can proceed intelligently, each boiler must be diagnosed individually, and here again the CO_2 meter and pyrometer have the advantage over the water meter and coal weigher, because the former can be connected to the individual boilers with comparatively little expense and trouble, whereas it is both expensive and generally quite difficult to make connections to the water meter so that individual boilers can be served separately. The coal may or may not be readily weighed out to any of the boilers separately from the others. It is evident from this that: Either method is better than no control at all; neither method is by itself adequate to produce maximum economic results; between the two, the chemical and physical method should have the preference because it is cheaper and more readily applied, and gives more directly useful information.

To attain maximum collective boiler efficiency every boiler must be treated as an individual. To be under proper economic control both its combustion and absorption efficiencies must be under constant observation. Maximum boiler efficiency cannot be maintained without knowing what every boiler is doing all the time. To this every combustion and boiler expert will agree; but opinions will no doubt differ as to the best means for effecting this constant observation. It would appear obvious that the most direct way is the best way. Combustion is a chemical phenomenon and should therefore be most effectively controlled by chemical means. Absorption is a physical phenomenon and is best controlled by physical means. The two principal instruments of observation are the CO_2 meter, a chemical instrument, and the pyrometer, which is a physical instrument. As a necessary auxiliary the double differential draft gage is required. Boiler draft and furnace draft are essential elements in the proper control of combustion and should be observed separately.

There is no such thing as a fixed adjustment in the operation of a boiler. The rate of combustion must be changed to keep the steam pressure right, the draft must be changed to keep the rate of combustion right, and the thickness of fire must be changed to keep the efficiency of combustion (percentage of CO_2) right. As the fuel and ash bed thickens, a stronger draft is necessary to keep the required rate of combustion, and there are numerous minor variables which require changes in the draft adjustments if combustion efficiency and the required boiler capacity are to be maintained; that is, maximum CO_2 and a uniform steam pressure. To insure these results CO_2 as well as boiler and furnace draft indicators must be placed at or near the boiler front within easy view of the fireman and in close proximity to the draft-regulating wheel or lever.

INSTRUMENTS NECESSARY FOR CONTROL OF FIRING

Since the firemen have no control over the temperature of the escaping gases a temperature indicator is not necessary. The CO_2 meters, pyrometers and boiler draft gage should be autographic-recording. In small and moderate-sized plants the recording gages should be placed in the engine room where they are under easy observation by the operating engineer. In large plants that can afford a control engineer, other arrangements will suggest themselves.

With such an outfit on every boiler the firemen have before them at all times the information necessary for intelligent and effective control of their fires, if properly instructed how to apply this information. The steam gage tells them when to increase or decrease the rate of combustion. The boiler draft tells them whether the air supply is right for the required rate of combustion. The CO_2 indicator tells them whether the thickness of the fire is right and the furnace draft indicates the condition of the fire. The volume of air required to burn a unit weight combustible with maximum combustion efficiency varies with the kind of fuel, construction of furnace and method of stoking, but for any given set of conditions a definite volume of air will consume a definite maximum weight of fuel completely. Since the boiler draft is a fair index to the rate of the air supply it is the proper basis for regulating the rate of combustion, and the rate of fuel supply must be increased or decreased to produce maximum combustion efficiency, to which CO_2 is the index.

The three autographic records, namely, those of CO_2, temperature of the escaping gas and the boiler draft, preferably on one chart, give the engineer in charge the following information at a glance: Whether normal combustion efficiency has been maintained; and if not, the precise time when it became abnormal and how long it remained so. This enables him to inquire into the cause, with the confidence born of knowledge, and to apply the proper correction. The continuous record further reveals in hand-fired boilers how often the fires were replenished, how long the fire-doors were left open, when the fires were cleaned and how long it took to clean them. In stoker-fired boilers changes in handling the fire are similarly revealed. The temperature record shows whether the absorption efficiency has continued normal; if not, the variation may be due to necessary variations in the rate of driving, and if so this will be revealed by the record of the boiler draft, which is an index to the rate of driving. Or it may be due to a breaking-down of the baffling, which is also instantly revealed by the boiler draft. The mucking-up of the heating surface is indicated by a gradual increase in the temperature of the escaping gases. The record of the boiler draft, in addition to its contributing value to the pyrometer record, becomes in combination with the percentage of CO_2 a very good index to the rate of combustion.

EXAMPLES OF APPLICATION OF INFORMATION GIVEN BY CHARTS TO CONTROL OF FIRING

If these three records are all made on the same chart, they can be readily integrated by means of the polar planimeter and the heat carried to waste by the dry gases quickly calculated by the application of a formula. Autographic boiler records, like steam-engine indicator cards, are of no value unless they are regularly scrutinized and correlated and the information they give promptly and intelligently applied. If the three essential records are all on the same chart this is neither difficult nor laborious.

Fig. 1 illustrates sections of such charts showing various relations of these three records to each other. The CO_2 records shown in Secs. 1 and 2 are facsimile samples of records from a boiler of the Manning type burning No. 1 buckwheat coal. Sec. 1, made when the recorder was first installed, shows that the firing was irregular and that the coal bed was kept too thin, through which holes quickly developed. The average CO_2 was scant 8 per cent. The reason for the low CO_2 being thus clearly revealed, the proper remedy at once suggested itself. The fireman was instructed to carry a little heavier fire and watch the CO_2 indicator, with the result shown in Sec. 2, which is a sample record for the same boiler after the fireman had been instructed and had learned to be guided by the CO_2 indicator in adjusting the thickness of fire to the draft necessary to maintain the required steam pressure. So guided, he had no difficulty in keeping the CO_2 at an average of about 12 per cent. Having the three principal records on the same chart their relation to one another is readily perceived, and it will be seen at a glance that the boiler draft is about 0.08 in. higher under the conditions represented by Sec. 1 than those by Sec. 2; also the gases left the boiler at a temperature 25 deg. higher when containing 8 per cent of CO_2 than when they contained 12 per cent., which shows that absorption efficiency increases with combustion efficiency.

RECORDS FOR COMBUSTION CONTROL OF A WATER-TUBE BOILER BURNING BITUMINOUS COAL

Secs. 3 and 4 of Fig. 1 show records representing a water-tube boiler burning bituminous coal. Sec. 3 illustrates conditions before, and Sec. 4, after, control by aid of CO_2. A glance at the CO_2 record will show that the fires carried were too thick. The low percentage of CO_2 (about 8.75 per cent.) was due principally to air infiltration, but to a considerable degree also to uneven firing producing high CO with low CO. Stopping up the air leaks and modifying the method of firing as illustrated by the record and using the CO indicator as a guide, the fireman had no difficulty in maintaining an average of over 13 per cent of CO with practically no CO.

Contrary to what was seen in Sec. 1 and 2 of the chart, both the temperature of the escaping gases and the boiler draft are higher when the conditions had been changed so as to result in the higher percentage of CO_2. This may at first seem contradictory; but a little study reveals the fact that both the boiler draft and the temperature of the escaping gases were rendered abnormally low by the flow of air (counter-draft) entering through the leaky setting. It is therefore necessary to make sure that the setting is made tight before these two factors can be relied upon as indices, respectively, of absorption efficiency and rate of combustion. Furthermore, a low stack temperature cannot be relied on as an index to absorption efficiency unless the gases contain a high percentage of CO_2.

AVERAGES OF FOUR TWENTY-FOUR HOUR TESTS

In Sec. 5, 6, 7 and 8 of the chart are recorded the averages of four 24-hour tests of a large water-tube boiler burning bituminous coal fired by Roney stokers. The coal was burned at four different rates of combustion; namely, 16.7, 18.25, 25.3 and 30.8 lb. per sq.ft. of grate surface per hour. The CO_2 averaged 14.68, 13.05, 14.28 and 14.69 per cent.; the boiler draft was 0.08, 0.12, 0.31 and 0.61 in. of water, and the temperature of the escaping gases averaged 483, 542, 662 and 636 deg. F., respectively. The efficiency attained in these tests was respectively 81.15, 77.45, 75.28 and 76.73 per cent.

Sec. 9 of this chart illustrates the relation the three records will take to one another if the demand for steam suddenly increases and the draft is adjusted to increase the rate of combustion to meet this increased demand, but the stoker is not speeded up sufficiently to supply the coal required. The flue-gas temperature will at once go up in response to the increased rate of combustion. The CO_2 will soon begin to drop, and if there is no CO_2 indicator to show what is happening it will continue to drop until the fireman discovers that the grate is getting bare and the stoker speed must be increased. He does so, but gives it a little too much speed and the CO_2 goes above the safe limit. If he is a good fireman, he will no doubt discover that also and finally get the right adjustment. Meanwhile considerable fuel has been wasted, first by excess air, and then by incomplete combustion. With a CO_2 indicator to guide him this would not have happened.

Sec. 10 illustrates how the boiler-draft and pyrometer records will at once reveal the sudden breaking down of a section of baffling. Sec. 11 shows how the average temperature and boiler draft would be affected if the baffling disintegrated gradually, and Sec. 12 indicates how the records would be likely to change if the boiler tubes were allowed to muck up gradually. These supposititious cases are given to show how the boiler draft and exit temperatures are affected by the same cause. Neither can be correctly interpreted without the other. Within practical limits of driving the maximum percentage of CO_2 can and should be maintained, whereas both the boiler draft and the exit temperature increase with the rate of driving. The exit gas temperatures vary from the normal from four distinct causes: Rate of driving, defective baffling, dirty heating surface and air infiltration. The record of the boiler draft at once reveals the true cause; the pyrometer simply reveals the fact. Low exit-gas temperature is generally taken to indicate absorption efficiency and the CO_2 record shows whether it is or not.

RECORDING INSTRUMENTS MUST BE IN PLAIN VIEW

Maximum efficiency cannot be expected, and it is doubtful whether it can be attained, unless the firemen have the means of knowing all the time how well they are succeeding in maintaining it. To this end it is necessary that they have in plain view, at or near the boiler front, a CO_2 indicator, a boiler-draft and also a furnace-draft gage. With these instruments to guide them the firemen can, after being properly instructed, always maintain the combustion conditions that will produce maximum efficiency under normal conditions, and do the best that can be done should the conditions not under their control for any reason become abnormal.

In addition to the three recording instruments, an Orsat apparatus is essential for determining the maximum percentage of CO_2 that can be carried without danger of an appreciable loss because of incomplete combustion; to diagnose the boilers for air infiltration at regular intervals, or in between, if deemed necessary; and to check up the CO_2 meters when their indications give cause for suspecting their accuracy. An Orsat is by itself quite inadequate as a control for the firing operations of a boiler plant, even when supplemented by sampling tanks, which combination, although better than nothing, cannot be considered more than a makeshift.

Flow of Water Through One and One-Half Inch Pipe and Valves

Bulletin No. 1 of the Engineering Experiment Station of Purdue University, Lafayette, Ind., gives the results of tests made by Frederick W. Greve, Jr., Assistant Professor of Hydraulics, on the loss of head of water flowing through 1½-in. pipe and valves. The tests were made on 40.513 ft. of commercial 1½-in. pipe and on three standard 1½-in. brass valves—a gate valve, a globe valve and a check-valve. The experiments to determine the loss of head due to straight pipe were made with water velocities ranging from less than 0.5 ft. per sec. to about 21 ft. per sec. Those on the gate and globe valves were for five different valve openings between full open and closed.

The conclusions reached as a result of the experiments are as follows: (1) The relation of loss of head to discharge can be represented by the formula $H = MQ^n$, where H is the loss of head in feet of water, Q is the discharge in cubic feet per second and M and n are values experimentally determined. (2) The values of M and n vary with restriction of area to flow, decreasing with increase of the ratio of rise of disk to nominal diameter of pipe. (3) Weisbach's coefficients for small gate valves give values of H that are too small. (4) A gate valve causes less loss of head than a globe valve and the losses are nearly equal when the ratio of rise of disk to nominal pipe diameter is equal to 0.23.

Merchant Marine Needs Two Thousand Men

Two thousand young Americans are needed at once to train for service in the United States merchant marine, it was announced Dec. 27 by the Shipping Board. Because of the rapid delivery of cargo vessels, which are now to be manned exclusively by merchant crews, there is an unusual demand for men to be trained, which must be met within a few weeks. Of the 2000 men now wanted, 1500 are to take the places of apprentices just sent to sea from the ships of the board's Atlantic training squadron, based at Boston, and 500 for its Pacific training ship "Iris," based at San Francisco.

Volunteers are requested to apply for enrollment to any of the board's drugstore recruiting officers or to write Henry Howard, its director of recruiting service, Boston, Mass.

At a large London factory at which some Lancashire boilers were converted from coal to fuel-oil firing, the water evaporation per pound of coal, having a calorific value of 11,451 B.t.u., was 7.22, whereas when working with the pressure system of oil burning, using an oil having a calorific value of 18,750, the evaporation per pound of oil reached 14.44 lb. The quantity of water evaporated per square foot of heating surface with coal was 3.3 lb., whereas, according to A. F. Baillie in a paper read before the Manchester Association of Engineers, the quantity evaporated with oil was over 7 lb., thereby increasing the boiler rating by over 100 per cent.

New Publications

BURNING STEAM SIZES OF ANTHRACITE WITH OR WITHOUT ADMIXTURE OF SOFT COAL

This is a technical paper, issued by the United States Fuel Administration and based on an article by William T. Frey, fuel engineer. The bulletin describes what must be done to burn steam sizes of anthracite or mixtures of this coal with soft coal so as to get the most steam from the least fuel. Information is given regarding the furnace equipment required for burning various percentages of steam anthracite and soft coal, these mixtures being 20 per cent. anthracite; a second addition being 20-40 per cent. anthracite, and a third over 40 per cent. anthracite. Data are given regarding the method of mixing soft with anthracite coal, the type of grate and air space that will burn the coal satisfactorily and the method of firing the mixture.

It is stated that with a good grade of steam anthracite it is possible to obtain almost as high efficiency as with bituminous coal provided the equipment and operation of the plant are suitable, and that large savings in the cost of fuel to generate steam are effected by substituting steam sizes of anthracite for the more expensive bituminous coal, but that the best results cannot be obtained unless the changes indicated are made so that the furnace becomes efficient for the anthracite. In the summary it is pointed out that a boiler plant designed for soft coal and operating on natural draft is capable of using 20 per cent. of steam sizes of anthracite mixed with soft coal without material loss in efficiency and without change of equipment, providing sufficient grate surface is available. Still higher percentages of fine anthracite may be mixed with the bituminous, provided suitable changes are made in the furnace equipment.

Personals

L. E. MacBryde has resigned as general manager of sales of the Foster Engineering Co.

Lieut. J. B. Howell has been mustered out of the artillery service and has rejoined the Bound Brook Oil-less Bearing Co. in the position he formerly held.

Thomas Holden, for several years with the Crandall Packing Co., has joined the Atlantic Coast selling force, representing the Cassco Bar-Metallic Packing Co., with offices at 45 Second St., Hoboken, N. J.

B. R. Sausen, formerly district manager of the Chicago office of Schütte & Koerting Co., is now associated with the Star Brass Works, of Chicago, engaged in sales promotion and research work of spray cooling equipment.

Nicholas Stahl, formerly connected with the power department of the Westinghouse Electric and Manufacturing Co., has succeeded the late Martin W. Kern as general engineer of the Narragansett Electric Lighting Co., of Providence, R. I.

Morris L. Cooke, Horace K. Hathaway, Boyd Fisher, Clyde L. King, Keppele Hall and John H. Williams announce the opening of an office as consulting engineers in management, in the Finance Building, South Penn Square, Philadelphia, Penn.

Lieut. Commander Frederick L. Pryor was presented with a gold watch by the released students at the demobilization of the naval section of the Students' Army Training Corps at Stevens Institute of Technology, at Hoboken, N. J., which occurred with appropriate ceremony on Dec. 21.

Horace N. Trumbull, who has recently received his discharge from the Engineer Officers' Training School at Camp A. A. Humphreys, Va., has been appointed advertising manager of the Wellman-Seaver-Morgan Co., of Cleveland, Ohio. Before entering the service, Mr. Trumbull was advertising manager of the SKF Ball Bearing Co., of Hartford, Conn.

Walter N. Polakov, consulting engineer, announces the founding of Walter N. Polakov & Co., Inc., consultants in power production methods, industrial investigations, labor problems, scientific record systems and production accounting. With the close of hostilities a number of capable engineers formerly associated with him joined the staff of the corporation at 31 Nassau St., New York City.

F. E. Bourget, who for the last thirteen months has been handling the distribution of bituminous coal for the U. S. Fuel Administration throughout Ohio, Michigan, Indiana and the West, has resigned to identify himself with the Interstate Coal and Dock Co., as its special sales agent at Cincinnati, Ohio. Prior to his connection with the Fuel Administration Mr. Bourget had been associated with railroad and coal companies in Chicago and Cincinnati.

Frederick Pearson, for the past 15 years associated with Marshall Field & Co., as advisory engineer in the development of its various manufacturing and merchandising enterprises in Chicago and elsewhere, has opened a consulting engineer's office in the Marshall Field Annex Building, Chicago. He will continue as advisory engineer to Marshall Field & Co., in addition to other interests engaging his service. Mr. Pearson's experience has been diversified, embracing electrical, mechanical and chemical engineering.

Frederick A. Scheffler, formerly connected with the New York offices of the Babcock & Wilcox Co., has become associated with the Fuller Engineering Co., designing and consulting engineers, Allentown National Bank Building, Allentown, Penn., and will make his headquarters at their New York office, 50 Church St. The Fuller Engineering Co. is making a specialty of applying pulverized fuel to boiler furnaces for the generation of power, and Mr. Scheffler, with his lifelong experience in boiler practice, will devote his particular attention to this work.

Miscellaneous News

The Siebel Institute of Technology announces that its refrigerating engineering course will start on Jan. 15 and continue for three months. The tuition fee for that time is $250. The institute is located at 960-962 Montana St., Chicago, Ill.

Business Items

The Wellman-Seaver-Morgan Co., of Cleveland, Ohio, has opened a San Francisco office at 415-417 Rialto Building, in charge of Norman S. Ross. Business originating from California, Nevada west of the 115th meridian, lower California and the counties of Josephine, Jackson and Klamath in Oregon will receive the prompt attention of Mr. Ross.

New Construction

PROPOSED WORK

Maine, Auburn—The Water Commissioners plan to build a pumping station. W. H. Sawyer, 11 Lisbon St., Lewiston, Engr.

Conn., Bridgeport—The Baptist Christian Union, 886 Main St., will install a steam heating system in the 4 story, 80 x 102 ft. home, which it plans to build on Main and Thomas St. Total estimated cost, $100,000. E. B. Caldwell, Jr., 886 Main St., Arch.

Conn., Durham—The Merriam Manufacturing Co. plans to rebuild its factory which was destroyed by fire. Plans include the construction of a new heating plant. C. S. Palmer, 191 Church St., New Haven, Arch.

Conn., West Hartford—The town will install a steam heating system in the 2 story, 100 x 100 ft. high school, which it plans to build on South Main St. Total estimated cost, $100,000. C. S. Lane, 1631 Boulevard, Chn. of Bldg. Com.

N. Y., Buffalo—The Donner Steel Co., Inc., 475 Abbott Rd., plans to build a 1 story addition to its power house. Estimated cost, $5000.

N. Y., Herkimer—The City Commission will receive bids about March 1 for the construction of a 1 story, 40 x 60 ft. boiler house. Equipment, such as pumps, heaters, etc., will be installed in same. Estimated cost, $15,000. H. B. Sweet, Clarendon Bldg., Utica, Engr.

N. Y., New York—B. Altman & Co., 5th Ave. and 34th St., will install a steam heating system in the 6 and 9 story, 75 x 200 ft. garage and warehouse, which it plans to build on 36th and 37th St., between 2nd and 3rd Aves.; plans include the construction of a cold storage building. Total estimated cost, $250,000. F. G. Frost, 19-25 West 44th St., Arch.

N. Y., New York—The Knickerbocker Hospital will install a steam heating system in the 7 story, 150 x 200 ft. hospital which it plans to build on 130th St. and Convent Ave. Total estimated cost, $500,000. Helmle & Corbett, 190 Montague St., Brooklyn, Engr.

N. J., Ampere—The Crocker-Wheeler Co. has had plans prepared for the construction of a 1 story, 40 x 55 ft. addition to its boiler room and power house, known as plant 8-A.

N. J., Boonton—The Board of Education will install a steam heating system in the 2 story, 100 x 150 ft. school building which it plans to build on old Boonton Rd. and Lathrop Ave. Total estimated cost, $125,000. Wilson Potter, 1 Union Sq., New York City, N. Y., Engr.

N. J., West New York—The Board of Chosen Freeholders of Hudson Co., Court House, Jersey City, has had plans prepared for the construction of a 1 story, 97 x 187 ft. power house and heating and lighting plant. Percie A. Vivarttas, 110 4th St Arch.

Fla., Jacksonville—The City Commissioners will receive bids until Jan. 10 for delivering and erecting complete, 1 surface condensing equipment with auxiliaries and equipment, having a capacity of 120,000 lb. of steam per hour in 1 unit, or 2 units, 60,000 lb. each per hour. L. E. Murphy, Engineers Bldg., Engr.

Ohio, Cleveland—The West Superior Co., c/o J. Larange, Williamson Bldg., will install a steam heating system, 6 elevators, etc., in the 17 story, 44 x 82 ft. office building which it plans to build on West 3rd St. and Superior Ave. Total estimated cost, $1,000,000. Lehman & Schmidt, 210 Electric Bldg., Engrs.

Ohio, Cleveland Heights (Warrensville P. O.)—The Board of Education will install a steam heating system in the additions which it plans to build to the schools on Noble, Fairfax and Roxboro Rds. Total estimated cost, $125,000 each. F. C. Warner, 768 Hippodrome Annex, Cleveland, Arch. and Engr.

Ohio, Massillon—The Massillon Electric & Gas Co., controlled by the Cities' Service Co., and operated by the Doherty Organization, 60 Wall St., New York City, N. Y., will rebuild its plant destroyed by an explosion last spring. Estimated cost, $30,000. J. F. O'Connor, Supt.

Ind., South Whitley—The Grip Nut Co. plans to build a power house in connection with the new plant which it plans to build. Total estimated cost, $300,000. Truman F. Miller, Mgr.

Mich., Marquette—The City Commissioners plan to issue $100,000 bonds for extensions to the electric-light system.

Mich., Saginaw—R. F. Johnson, Comr. of Light, Water and Sewers, will soon receive bids for installing auxiliary pumping unit in the West Side pumping station; also laying water mains in Porter St., from Bristol St. north, and in Niagara St., from Court to Mackinaw St. Estimated cost, $25,000. Part of the work will be done by day labor. H. H. Eymer, City Hall, Engr. Noted Dec. 10.

Ill., Cicero—The Board of Education, 5144 West 24th Pl., has had plans prepared for the construction of a 2 story, 40 x 169 ft. school and boiler room, on 57th St., between 22nd and 23rd Pl. Estimated cost, $60,000. Ashby, Ashby & Schulse, 178 West Jackson Blvd., Chicago, Arch.

Ill., Ozark—The City Council plans to construct a plant sufficiently large to light the city's main arteries and supply a limited service to the business section.

Wis., Manitowoc—William Rahr's Sons Co. plans to build a 1 story, 75 x 90 ft. addition to its boiler house. W. J. Raeuber, Arch.

Wis., Milwaukee—The Plankington Packing Co., Muskego Ave. and Canal St., is receiving bids for the construction of an addition to its engine room. C. H. Kane, Union Stock Yards, Chicago, Ill., Arch.

Wis., Waukesha—The Board of Education plans to rebuild the heating plant in the high school. Sidney Putney, Pres. Van Ryn & DeGelleke, 726 Caswell Bldg., Milwaukee, Arch.

Minn., Hibbing—The Hibbing Electric Light Co. plans to erect a new 2-story lighting plant and central building to supply the needs of the town. Estimated cost, $400,000. Charles Foster, Mgr.

Minn., Ortonville—The Ortonville Electric Power Co. plans to build a plant. Estimated cost, $75,000.

Kan., Larned—The Pawnee Power & Water Co., c/o Nathan L. Jones, owner, incorporated mith $150,000 capital, plans to build a power plant to supply light and power to 7 cities and power for pumping purposes.

Kan., Logan—The city plans an election soon to vote on a $15,000 bond issue for improvements to the electric-light and water-works plants.

S. D., Mitchell—The Trustees of the Dakota Wesleyan University will receive bids in the spring for the construction of a power house. F. H. Ellerbe, 692 Endicott Bldg., St. Paul, Minn., Arch.

Mo., St. Louis—The Christian Brothers College, 5270 Page Ave., is having plans drawn for building and equipping a power house to provide heat for college buildings and power for laundry, bakery, etc. Estimated cost, $50,000. Henry P. Hess, 4811 Cote Brilliant Ave., Engr.

Mo., St. Louis—The General Motor Corp., Boyer Campbell Bldg., Detroit, Mich., will install a heating plant in the 3-story factory which it plans to build on Natural Bridge Rd. and Union St. W. H. Kilpatrick, Flint, Mich., Engr.

Mo., St. Louis—The Union Electric Light & Power Co., 12th and Locust St., will alter its boiler house. Estimated cost, $15,000. John Hunter, Ch. Engr. Power Sta.

Ark., Clarendon—The Commonwealth Power Co. plans to erect a power plant on the river. A. Perry, Mgr.

Tex., Sherman—The Trustees of Carr-Burdette College plan to install a heating plant.

Tex., Weatherford—The city plans to rebuild the electric light plant recently damaged by fire.

Colo., Sterling—The city plans to build a heating and lighting plant.

N. Mex., Ft. Stanton—J. A. Wetmore, Superv. Arch., Treasury Department, Washington, D. C., will soon award the contract for the installation of new engine, generator, etc., in the U. S. Public Health Sanitarium here.

Utah, Monti—The Town Council plans to build a hydro-electric plant and enlarge the present flume and distribution lines. Estimated cost, $10,000.

Ariz., Florence—The city plans to improve the water-works and lighting plants. Estimated cost, $80,000. Burns & McDowell, Interstate Bldg., Kansas City, Mo., Engrs.

Wash., Seattle—The Skinner & Eddy Corp., Railroad Ave., plans to build a 1-story, 100 x 220 ft. power house and blacksmith shop. Estimated cost, $7000.

Cal., Los Angeles—J. P. Vroman, Secy. Dept. of Pub. Wks., will receive bids until Jan. 24, for furnishing sheet steel rivets and pipe section for pipe line and penstocks for power plant No. 2 in San Francisquito Canyon. Estimated cost, $75,000. Former bids rejected. Noted Dec. 10.

P. E. I., Charlottetown—The Department of Public Works has awarded the contract for the installation of a heating system in the Military Hospital here to the Bruce Stewart Co., Ltd.

Ont., Cobalt—M. J. O'Brien, Ltd., Renfrew, capitalized at $20,000,000, is having surveys made at the Des Quinze water power, about 25 miles northwest of Cobalt, for a power development.

CONTRACTS AWARDED

N. Y., New York—The Board of Education, 500 Park Ave., received bids for installing heating and ventilating systems in P. S. 32, (Bronx Borough), from Daniel J. Rice, 103 Park Ave., $61,383; John C. Williams, Inc., 233 Broadway, $62,797; Gillis & Geoghegan, 537 Broadway, $66,578. C. B. J. Snyder, Municipal Bldg., Engr.

N. Y., New York—(Borough of Brooklyn)—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing electric lighting system in the nurses' quarters, at the Naval Hospital here, to the E. J. Electric Installation Co., 221 West 33rd St., New York City. Estimated cost, $1668.

N. Y., New York—(Borough of Brooklyn) The Commissioner of Water Supply, Gas & Electricity, Municipal Bldg., Manhattan, received only bid for reserving and furnishing electric generating capacity, current and equipment for the use of high pressure fire service station for year 1919, from the Edison Electric Illuminating Co., 360 Pearl St., Brooklyn, $27,400. S. H. Beardsley, Municipal Bldg., Engr.

N. Y., Syracuse—The Standard Oil Co., North Beach St., has awarded the contract for the construction of a 1 story, 13 x 26 x 50 ft. pump and boiler house, to the Walsh Construction Co., 403 Herald Bldg. Estimated cost, $3500.

Penn., Philadelphia—The Pennsylvania R.R., Broad St. Station, has awarded the contract for the construction of a 1 story, 15 x 40 ft. addition to power house, to William Steel & Sons, 1600 Arch St.

Penn., Reading—The Carpenter Steel Co., River Rd. and Exeter St., has awarded the contract for the construction of a power house to the Beard Construction Co., 5th and Walnut St.

Va., Clinchfield—The International Coal Co. has awarded the contract for the construction of a coal byproducts plant to consist of boiler house, gas ovens, etc., to Ford, Bacon & Davis, 115 Broadway, New York City, N. Y.

Mich., Detroit—The Board of Fire Commissioners, Wayne and Larned St., has awarded the contract for the construction of a 2-story, 65 x 80 ft. engine house, to Max Bartholomaei & Sons Co., 466 East Warren Ave.; heating and plumbing let to M. B. O'Connor, Penobscot Bldg.

Mich., Port Huron—The city has awarded the contract for furnishing and installing two 6,000,000 gallon centrifugal pumps and two 200 h.p. motors at the water-works, to Fairbanks-Morse Co., Lafayette Blvd., Detroit. Estimated cost, $10,200. Noted Nov. 26.

Ill., Great Lakes—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a power house here, to Hanson Bros., 127 North Dearborn St., Chicago. Estimated cost, $10,000.

Ia., Grinnell—The St. Francis Hospital, Clinton, has awarded the contract for the construction of a 2-story, 40 x 146 ft. hospital to include a 1-story, 38 x 50 ft. boiler house, to Lighter Bros., 611 Security Bldg., Cedar Rapids; heating and plumbing, to Roy Anderson, Grinnell.

Ia., Sioux City—Swift & Co., Union Stock Yards, Chicago, Ill., has awarded the contract for the construction of an addition to its cold storage building here, to F. T. Leeder, 615 5th St. Estimated cost, $10,000.

Cal., Martinez—The city has awarded the contract for the construction of an 18 x 24 ft. pump house, to M. P. Holmes, Martinez, $2800; 2 triplex pumps having a capacity of 270 gallons per minute, driven by electric motors, to Fairbanks-Morse Co. 651 Mission St., San Francisco, $6015.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b mines are as follows

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3 40	Boiler	$2 65
Rice	2 90	Barley	2 40

All rail rate to Boston is $2 86

BITUMINOUS

Bituminous, $8 to $8 75

Pocahontas and New River, f.o.b. Boston, $8 35 to $8 90

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows

	Circular	Individual		Circular	Individual
Pea	$6 55	$7 30	Broken	$7 80	$8 55
Buck	5 10	5 90	Egg	7 70	8 45
Rice	4 65	5 10	Stove	7.95	8 70
Barley	4 15	4 30	Chestnut	8 05	8 80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows

	Mine Gross	F O B N Y Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3 30	$5 45
Upper Potomac, Cumberland & Piedmont Fields.		
Run of Mine	3 08	5 23
Prepared	3 36	5 51
Slack	2.80	4 95

Quotations at the upper ports for both bituminous and anthracite are 5c higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr Ago
Pea	$4 80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2 15
Buckwheat	3 40	2.90	4.45	3.50
Rice	2 90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10 other rates p 95

PRICES—MATERIALS AND SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft Lengths
Underwriters' 2½-in	85c per ft
Common, 2½-in	25%

Air	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0 65	$0 40	$0 30

Steam—Discounts from List

First grade	15%	Second grade	25%	Third grade	33⅓%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	50%	Best grade	30%
Standard	40%		

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	30 to 50%	40%
Chicago	45%	40%
Birmingham	35%	35%
Denver	35–5%	30%

RAWHIDE LACING—40%.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0 99
Asbestos for high-pressure steam	1.76
Duck and rubber for piston packing	1 10
Flax, regular	99
Flax, waterproofed	1 21
Compressed asbestos sheet	1 10
Wire insertion asbestos sheet	1 32
Rubber sheet	66
Rubber sheet, wire insertion	99
Rubber sheet, duck insertion	55
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1 21
Asbestos wick, ½- and 1-lb. balls	75

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	90
10-in.	1.30	3½-in.	1 05

85% magnesia high pressure		List
For low-pressure heating and return lines	4-ply	58% off
	3-ply	60% off
	2-ply	62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5¼	6 9	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4 1	3¼	5¼
Gear	4½	9	4½	9 5	8	9
Car journal	22(gal.)	21 (gal.)	3½	4.5	5	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8 50 to 12 00	12 00	13 00	11.50 to 14 00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13¼	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago		
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago	St Louis
Raw in barrel	$1.64	$1 20	$1 90	$1 25	$1 77	$1.18	$1 66
5-gal. cans	1 89	1 30	2 00	1 40	1 97	1 28	1.69

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	14 00	14 50	12 25	12 50	14 00	12 00
15- and 50-lb. kegs	14.25	14 75	12 50	12 75	14 25	12 25
52½-lb. keg	14.50	15.00	12 75	13 00	14 50	12 50
2-lb. cans			14 25	14 00	16 00	14 50
1-lb. cans			14 25	14 50	17 00	14 50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel 7/16 and smaller	40%	45–5%	40%
Tinned	30%	45–5%	40%

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York...$5.675 Cleveland...$5.15 Chicago...$5.67 Pittsburgh... 4.65

Coneheads, same sizes:

New York...$5.775 Cleveland...$5.25 Chicago...$5.77 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00	at Chester, Penn.
Chrome cement	net ton	65.00	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48	at Clearfield, Penn.
Magnesite, dead burned	net ton	37 50	at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	90.00	at Chester, Penn.
Silica brick	net ton	45–55	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $40 to $55.

Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.

Chicago—Second quality, $25 per ton.

Denver—Silica, $35 per 1000.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87 00	70.00	80 00	93.00	75.00	70 00
Commercial	42.00	40.00	21.50	21.50	15 00	25 00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$14.00
Cleveland	20.00	15.00
Chicago	19.00	13 50

In coils an advance of 50c. usually is charged.

Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft	7.65	6 85	6 10	6 85
7 in by 35 ft	11 10	10 00	8.95	10 00
8 in. by 35 ft	12.65	11 35	10 10	11 35
7 in. by 40 ft	12.85	11.50	10 20	11 50
8 in. by 45 ft	18 90	16 90	15 00	16 90
8 in. by 50 ft	22.65	20 30	18.00	20.30

10c. higher freight rates on account of double loads.

For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft	$9.00
12-in. butts, 6-in. tops, length 30-40 ft	11.50
12-in. butts, 6-in. tops, length 41-50 ft	12.50
14-in. butts, 6-in. tops, length 51-60 ft	21.00
14-in. butts, 6-in. tops, length 61-71 ft	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Inches	Steel Black	Galvanized	Inches	Iron Black	Galvanized
⅛, ¼, and ⅜	47%	20½%	¾ to 1½	36%	20%
½	51%	36½%			
¾ to 3	54%	40½%			

LAP WELD

2	47%	34½%	2	29%	15%
2½ to 6	50%	37½%	2½ to 6	31%	18%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	43%	25½%	¾ to 1½	36%	21%
½	48%	35½%			
¾ to 1½	52%	39½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	45%	33½%	2	30%	17%
2½ to 4	48%	36½%	2½ to 4	32%	20%
4½ to 6	47%	35½%	4½ to 6	31%	19%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	40%	28%	41%	26%	41 1%	26 1%
3½ to 3 in. steel lap welded	36%	25%	37%	23%	37 1%	23 1%

Malleable fittings Class B and C, from New York stock sell at list + 15%.

Cast iron, standard sizes, 5% off

BOILER TUBES—The following are the prices for carload lots f.o.b. Pittsburgh, [illegible], after Jan. 1

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	57	3½ to 4½ in.	15½
2½ to 3¼ in.	47	3 to 3¼ in.	+ 2
2¼ in.	20½	2½ to 2¾ in.	+ 4½
1¾ to 2 in.	16	2 to 2¼ in.	+ 19½
		1¾ to 1⅞ in.	+ 32

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$334	1⅞ in.	$214
1¼ in.	274	2 to 2½ in.	184
1½ in.	264	2¾ to 3¼ in.	174
1¾ in.	214	4 in.	194
		4½ to 5 in.	214

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

ARMORED CABLE

B.&S. Size	Two Cond. M Ft	Three Cond. M Ft	Two Cond. Lead M Ft	Three Cond. Lead M Ft
No. 14 solid	$104 00	$138 00	$164 00	$222 00
No. 12 solid	135 00	170 00	211 00	290 00
No. 10 solid	185 00	235 00	255 00	325 00
No. 8 stranded	235 00	325 00	345 00	450 00
No. 6 stranded	370 00	472 00	625 00	

From the above lists discounts are

Less than coil lots	Net List
Coils to 1,000 ft	10%
1,000 ft. and over	15%

BATTERIES, DRY Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0 40
12 to 50	38
50 to 125 (bbl.)	35
125 (bbl.) or over	32

CONDUITS, ELBOWS AND COUPLINGS Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows.

	Conduit		Elbows		Couplings	
Size, In	Black 1,000 Ft and Over	Galvanized 1,000 Ft and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜			$18 24	$19 38	$5 76	$6 12
½	$76 50	$81.60	18 24	19 38	6 72	7 14
¾	101 20	108 10	24 00	25 50	9 60	10 20
1	149 60	159 80	35.52	37 74	12 48	13.26
1¼	202 40	216 20	45 45	48 15	17 17	18 19
1½	242 00	258 50	60 60	64 20	21 21	22 47
2	325 60	347 80	111 11	117 70	28 28	29 96
2½	514 80	549 90	181 80	192 60	40 40	42 80
3	673 20	719 10	484 80	513 60	60 60	64 20
3½	837 20	892 40	1,070 60	1,134 20	80 80	85 60
4	1,013 70	1,079 10	1,237 25	1,310 75	101 00	107 00

5% cash 10 days.

From New York Warehouse—Less 5% cash

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In	Feet per Coil	List, Ft.	
7/32	250	$0 05½	Coils . . . 55% Off . . Less coils, 40% off
¼	250	06	
⅜	250	09	
½	200	.12	
⅝	200	15	
¾	150	18	
1	100	25	
1¼	100	33	
1½	Odd lengths	40	
2	Odd lengths	55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L	$0 11	T. P. to D. P. S. B	$0.24
D. P. M. L	18	T. P. to D. P. T. B	38
T. P. M. L	26	T. P. S. B.	33
D. P. S. B	19	T. P. D. B	54
D. P. D. B	37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp
D. P. M. L	$0 33	$0 84	$1 68
T. P. M. L	48	1 20	2 40
D. P. S. B	42	1.05	
T. P. S. B	81	1.80	
D. P. D. B	78	2 10	
T. P. D. B	1 35	3.60	
T. P. to D. P. D. B	90	2.52	

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22.00
No. 16 cotton twisted	28 40
No. 18 cotton parallel	25 00
No. 16 cotton parallel	32 00
No. 18 cotton reinforced heavy	35 00
No. 16 cotton reinforced heavy	42 00
No. 18 cotton reinforced light	30 00
No. 16 cotton reinforced light	36.00
No. 18 cotton Canvasite cord	29 00
No. 16 cotton Canvasite cord	35 00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp	100	$0 25
35-amp. to 60-amp	100	35
65-amp. to 100-amp	50	90
210-amp to 200-amp	25	2 00
25-amp. to 400-amp	25	3 60
5-map to 600-amp	10	5 50

600 Volt	Std. Pkg.	List
3-amp. to 30-amp	100	50
35-amp. to 60-amp	100	60
65-amp. to 100-amp	50	1 50
110-amp. to 200-amp	25	2 50
225-amp. to 400-amp	25	5 50
450-amp. to 600-amp	10	8 00

Discount:	
Less 1-5th standard package	30%
1-5th to standard package	40%
Standard package	52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$5 25
0-30 ampere, less than standard package	7 00

LAMPS Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B Watts	Plain	Frosted	No. in Package	Mazda C Watts	Clear	Frosted	No. in Package
10	$0 35	$0 38	100	75	$0 70	$0 75	50
15	35	38	100	100	1 10	1 15	24
25	35	38	100	150	1 65	1 70	24
40	35	38	100	200	2 20	2 27	24
50	35	38	100	300	3 25	3 35	24
60	40	45	100	400	4 30	4 45	12
100	85	92	24	500	4 70	4 85	12
				750	6 50	6 75	8
				1000	7 50	7 75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

		Each
Hubbell, porcelain No. 5406,	standard package 250	$0 24
Hubbell composition No. 5467,	standard package 50	.32
Benjamin swivel No. 903,	standard package 250	.20
Hubbell current taps No. 5638,	standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$13 00	$16 00	$18 00	$32 00
12	16 70	18 80	22 00	36 85
10	23 52	26 10	29 10	50 60
8	31 00	36 40	40 20	70 10
6			62 00	
4			83 10	
2			122 40	
1			161 30	
0			189 68	
00			230 00	
000			282 40	
0000			345 50	

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$17 00	$21.00	$39 40	$21 00	$16 00	$33 00	$13 00	$17.40	$36.80
10	25 65	28 90	64 75	27 20	31 00	69 00	21 40	24 40	42.75
8	36 45	40 25	88 45	38 00	42.00	78 00	42 35	44 35	
6	57 40	61 70			65 00	130 00	64 60	74 60	
4	83 40	88 70			93 00		101 75	106 05	
2	126 60	132 80			140 00		151.50		
1	164 15	172 40			182 00		201.00	258 50	
0		206 80			242 00		276.00	285 00	
00		278 80			290 00		317.00	330 00	
000		341 65			360 00		417.00	428 50	
0000		417 05			435 00		516.00	516.00	

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

⅛ In. or Pendant Cap			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0 60	$0.39	$0.36	$0 66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	50c. lb
No. 18 B.&S. regular 1-lb. coils	52c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0 42	$0 68	$1.02	$1.36
60	.74	1 22	1.84	2.44
100	1.50	2 50	3 76	5.00
200	2.70	4 50	6 76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	.70	1 06	1 60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6 76	10 14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
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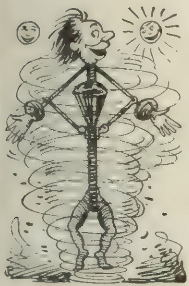
POWER

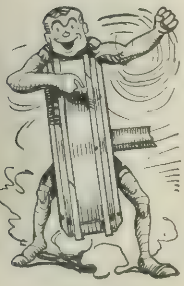
Volume 49 New York, January 14, 1919 *Number* 2

THE MASTER'S HAND

BY BENJAMIN O. WILKINS

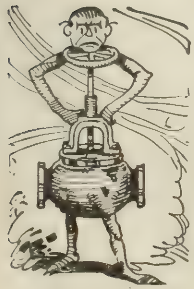


The Governor: "I dance serene,
On top of all the great machine,
And glance around, by night and day,
To see that things don't run away."



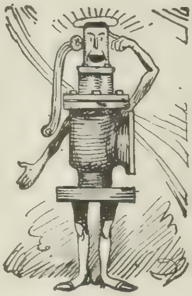
"Who? You? You're nothing but a shirk!
It's me, The Piston, does the work.
I'm here with might to push and pull,
And make each stroke count to the full."

"Oh, no! You but obey *my* will,"
The haughty Steam Chest hisses shrill.
"I am the one that gives the strength
To shove you out the guide's full length."



And then the Throttle Valve got cross:
"I'm over you, and I'm the boss
Of all your energy and zest.
Now tell me, which of us is best?"

The Flywheel hummed, "Here, think of me—
Momentum lost, where would *you* be?
Who drags you on with iron nerve
Up from the bottom of the curve?"



The Safety Valve spoke up and said,
"Without me and my knowing head
The lot of you would fly apart,
And land in the old-iron mart."

The Engineer came over then
And said, "She's got a grouch again.
Why! That blamed oiler's shaken loose!
Without the grease she's little use."

A Visitor was looking in.
He shook his head: "Of all the din!
What good would that huge engine be
Without the man, to oversee?"

Generator Wreck at St. Paul

ON TUESDAY morning, Dec. 10, in the St. Paul plant of the Northern States Power Co. a 2000-kw. generator which had been in service for nine years was completely damaged. The trouble originated by a workman short-circuiting a 13,000-volt feeder in Minneapolis connecting the St. Paul and Minneapolis plants. The St. Paul plant, in which were operating one 1000-kw. and one 2000-kw. steam-turbine units, excited from a motor-generator set, was subjected to a short-circuit of such proportions and duration that the excitation was practically lost on both the turbo-generators. About the time the steam-driven exciter was put in operation the generator end of the 2000-kw. unit completely wrecked itself. It is noteworthy that the steam end of the turbine remains intact, as clearly shown in Fig. 1, although probably the shaft has been sprung and the casting supporting the turbine bearing has been cracked. The generator and its bedplate are completely wrecked. The field shaft is broken off at each end of the field, and three polepieces were thrown off. The inboard and outboard bearings are demolished. The completeness of this generator wreck is shown in Fig. 1, and Fig. 3 is a view of the spindle shaft that was twisted off between the steam end and the generator.

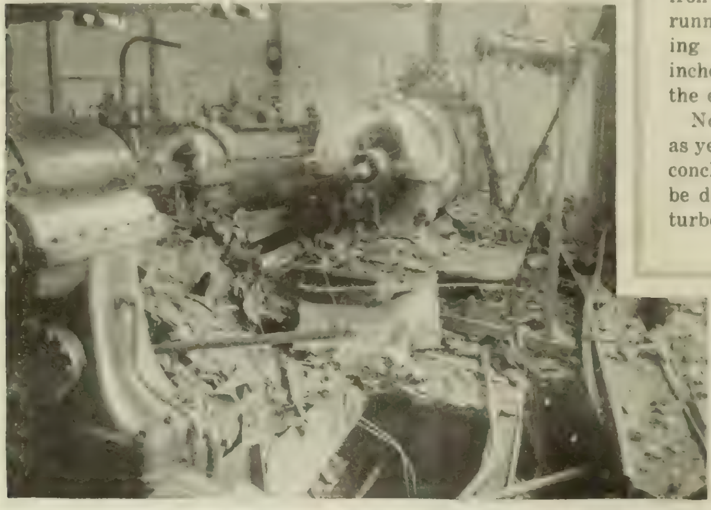


FIG. 1. VIEW OF THE TURBINE ROOM AFTER THE ACCIDENT

In addition to the units mentioned there were in the station another 1000-kw. machine and a 4000-kw. unit, neither of which were in operation. The turbine driving the wrecked generator was a Westinghouse type C machine (a type abandoned several years ago, the patterns for which had been destroyed). At a speed of 1200 r.p.m., the generator delivered three-phase 60-cycle 2200-volt current. It has a built-up field having six polepieces of the bolted-on type. Each polepiece was held by 14 bolts, 2½ in. diameter. The unit weighed 169,000 lb., the turbine weighing 120,000 lb. and the generator 49,000 pounds.

Pieces from the wreck were thrown through the walls and about the power house, one complete section of wall near the generator being blown out. One piece cut the 20-in. I-beam of the overhead crane, allowing it to fall on the wreck. Another piece demolished the benchboard from which an operator had turned but a few seconds before. A large section of stator iron was shoved against the 100-kw. set running next to the wrecked machine, moving it and the bedplate more than two inches at the generator end and cracking the end housings of the generator.

No obvious or exact determinations have as yet been given for this wreck, but certain conclusions that may be illuminating can be drawn. The 2000-kw. and the 1000-kw. turbo sets were operating noncondensing and in parallel. The St. Paul plant was tied in with Minneapolis through one 13,000-volt three-phase feeder approximately ten miles long. The St. Paul turbo-generators were excited from a motor-generator set from which some power-house lighting was also done.

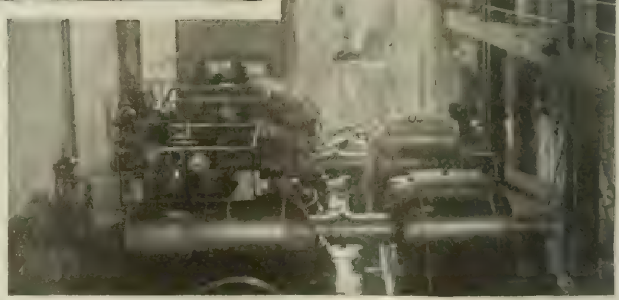


FIG. 2. WHERE THE GENERATOR WENT THROUGH THE WALL

A "short" occurred in Minneapolis by a man getting across this 13,000-volt feeder. This "short" remained on for sufficient time to allow starting the steam-driven exciter in the St. Paul plant—probably five minutes. It caused a slowing down and a reduction in frequency and voltage of the two units in operation. The motor-generator excitation voltage was so low that the lamps on the circuit were merely red, causing the short-circuited turbo sets to drop their load, though the turbine was getting all the steam it could pass.

With these conditions one of three things happened:

1. The machines being subjected to this short-circuit for several minutes caused the mechanical collapse of the 2000-kw. unit.

2. The machines remained on the short-circuit until it was cleared, and the entire system, many times 3000-kw. capacity, endeavored to bring them into step.

3. The machines under this terrific short-circuit overload, dropped their load, due to loss of excitation, and the 2000-kw. unit overspeeded until the generator exploded.

Assumptions must again be made, as no information is available as to why the circuit-breakers did not cut off this overload instantly, but obviously allowed the short to remain on both the St. Paul and Minneapolis systems until at least the 2000-kw. generator was wrecked. The first reason given can be dismissed, as a short-circuit located at the end of a ten-mile feeder would not wreck mechanically the machine, and as no smoke or blaze was noticed, the machine was not burned out electrically. This is also confirmed by the fact that the 1000-kw. machine in parallel on this short was not injured. It is difficult to justify No. 2, that the wreck was due to the machines getting out of step with the system, for if this was sufficient to wreck the 2000-kw. generator, it certainly would have had some effect on the 1000-kw. unit. If it was sufficient to twist off the 8-in. shaft on the larger machine, it would likely have left some indications of strain on the smaller set. Inspection showed no internal damage to the smaller unit.

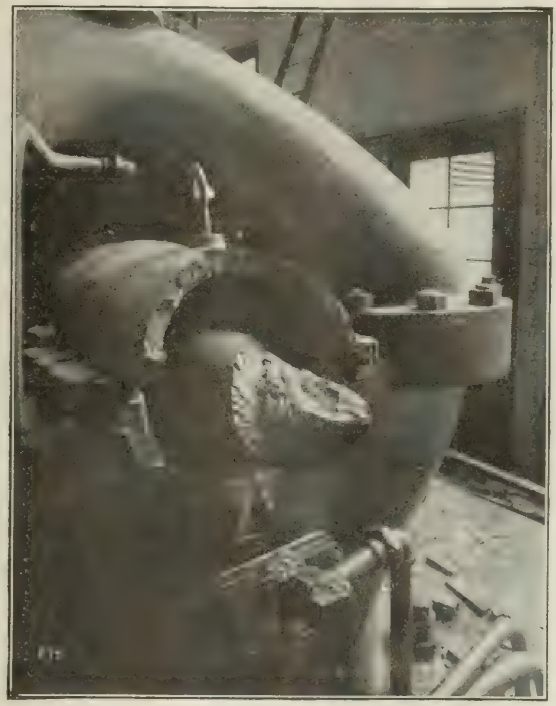


FIG. 3. THE SPINDLE TWISTED OFF

Overspeeding, as per No. 3, seems by far the most probable cause. The turbines had been in service nine years, were built for 150 lb. steam pressure and no superheat, and were actually operated under 185 lb. steam pressure, 100 deg. superheat and 6 lb. back pressure. Owing to this changed steam condition, the company operating the plant had dismantled the automatic safety stop on the three type C machines, depending upon the system to lock them electrically and load changes to be handled by the regular governor operating on the primary and secondary valves. Both of these valves were opened to the maximum on the short and the machines operating at much reduced speed. When the load was dropped, owing to the loss of excitation, the generators instantly speeded up. The governor on the 1000-kw. turbine closed its valves and kept the machine at normal speed under steam. The valves of the 2000-kw. turbine did not close tight, or for some other reason the governor did not control this machine. The overspeed trip actually tripped, but as the automatic safety stop was dismantled, it was useless and the generator reached a speed where the fourteen 2½-in. bolts per field pole, were elongated and the poles struck in the stator, which twisted off the shaft and wrecked the machine.

Only one operator in the power house was slightly injured. The operator in Minneapolis who short-circuited the line was, of course, electrocuted. The property damage is about $50,000, covered by insurance. There was no material interruption to the electric service. The heating system into which the machines were exhausting, was discontinued for about one hour, but owing to mildness of the weather, this was immaterial. After one has carefully gone over the details of the accident, he sees that it is more spectacular than fraught with circumstances for technical thought. The lesson to be drawn from the accident is one for operators chiefly; namely, that the crew should exercise constant care to see that in the event of loss of load, the turbine will shut itself down without damage.

Sir Adam Beck, chairman of the Public Hydro-Electric Power Commission of Ontario, Canada, which is now serving over 200 cities, reports that power developed under public ownership on the Canadian side of the Niagara Falls sells at a wholesale price of $9 per horsepower, while the same power developed under private ownership just across the river on the American side sells at $18.

The best way to lubricate gears is to clean them and then paint the cogs with a stiff brush. Where this is not possible, the lubricant may be poured on the cogs while the gears are running. The lubricant should be poured where the gears mesh.

Behavior of Steam in a Compound Engine

Did you ever wonder how the designer of a compound engine computed and decided the cylinder proportions to be used?

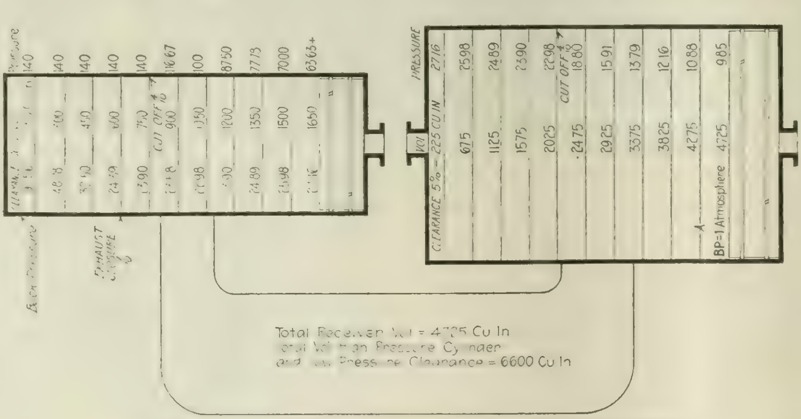
Did you ever wonder why the receiver pressure is what it is, in the engine you have to do with?

Can you explain why the receiver pressure is the same for all variations in load, if it is, or why it varies, if it does?

In this article is an informal discussion of these points, in which the influence of valve adjustment and governor control is pointed out.

A STUDY of the pressures at various stages or points of the stroke in an engine becomes absorbing when once begun, and is one of the numerous questions that must be decided or worked out by the designer before the engine is completed. Suppose the cylinder dimensions of a tandem-compound engine have been fixed at 100 sq.in. area for the high pressure with 10 per cent. clearance, and 300 sq.in. for the low pressure with 5 per cent. clearance, both having a common stroke of 15 in. Dividing the stroke into ten equal parts gives 150 cu.in. for each one-tenth of the high-pressure cylinder stroke and 450 cu.in. for the low-pressure cylinder. Using a receiver having a capacity of 4725 cu.in., the total volume of the high-pressure cylinder plus the receiver and the clearance space for the low-pressure cylinder (with the low-pressure admission valve just opened) would be 1650 (the high-pressure cylinder) plus 4725 (the receiver) plus 225 (the low-pressure clearance volume), a total of 6600 cu.in. The steam pressure is fixed at 140 absolute (125 gage). Both valves are operated by the same eccentric or automatic governor. Under these conditions what will be the receiver pressure and the terminal pressure when operating noncondensing with a cutoff taking place at $\frac{4}{10}$ stroke in each cylinder?

Starting the engine after a thorough warming up and with steam at atmospheric pressure (15 lb. absolute) in the receiver space, the pressures at various points of the first revolution of the engine would be as shown in the illustration, neglecting condensation losses and leakage and treating the steam as if it were a perfect gas, following the $P \times V =$ constant law. In other words, a change in the space or volume occupied by a given quantity of steam changes its pressure proportionately, so that the original volume (V) multiplied by the original pressure (P) and divided by the new volume will give the resultant pressure. Then if the steam is cut off at the point when the initial steam occupies one-half the final volume of the cylinder at the end of the stroke (clearance volume included), the final pressure will be one-half the initial pressure. If cutoff at one-fourth the final volume, the final pressure will be one-fourth the initial, etc. Steam does not follow this law exactly, but it is the basis of all calculations of this nature. The clearance space in the high-pressure cylinder, being 10 per cent., is equal to $\frac{1}{10}$ the piston's displacement, or 1½ in., and cutoff taking place at $\frac{4}{10}$ of the piston's travel, there is at cutoff a volume of 750 cu.in. (600 cu.in. by piston and 150 cu.in. clearance) filled with steam at 140 lb. After cutoff the pressures at each succeeding $\frac{1}{10}$ of the stroke, or 1½ in. the piston travels, will be 116.67, 100, 87.5, 77.78, 70 and 63.636 pounds respectively. When the high-pressure exhaust opens, this 1650 cu.in. of steam expands into the receiver (4725 cu.in.) and clearance space (225 cu.in.) of the low-pressure cylinder in addition to the volume of the high-pressure cylinder (or a total of 6600 cu.in. space), but the receiver and low-pressure clearance space, amounting to 4950 cu.in., is filled with steam at atmospheric pressure, or 15 lb., so that 4950 × 15 equals 74,250, and the high-pressure cylinder discharges 1650 × 63.636 (or 750 × 140) equals 105,000. The sum of the two is 179,250 and this divided by 6600 (the total volume) gives a combined pressure of 27.16 at the beginning of the low-pressure stroke. As the two pistons move forward, the steam pressure decreases proportionately as the total volume occupied by the steam increases. The increase in volume for each $\frac{1}{10}$ of the return stroke is 300 cu.in.; since the low-pressure volume increases 450 cu.in. and the high-pressure volume decreases 150 cu.in., the net increase is the difference, or 300 cu.in. This rate of increase continues up to the point of cutoff of the low-pressure cylinder, and the corresponding pressures are: Begin-



COMPUTATION OF PRESSURES FOR GIVEN CONDITIONS ning of stroke, 27.16 lb.; at the end of the first stage ($\frac{1}{10}$ stroke) (1), 25.98 lb.; (2), 24.89; (3), 23.90; (4), 22.98, when the low-pressure steam valve closes and the total remaining volume is reduced by 150 cu.in. per stage until the high-pressure exhaust closes, at $\frac{7}{10}$ of the return stroke, and the steam pressure increases proportionately to (5), 23.58; (6), 23.90; and (7) 24.39, when the exhaust closes and compression within the high-pressure cylinder brings the pressure (compression) at $\frac{8}{10}$ to 32.50; (9), 48.78; and (10), 97.56 at the end of the high-pressure return stroke. While this has been going on in the high-pressure cylinder, the steam isolated in the low-pressure cylinder after cutoff has taken place, expanded from 22.98 at cutoff as follows: (5), 18.80; (6), 15.91; (7), 13.79; (8), 12.16; (9), 10.88; and (10) 9.85 lb. pressure at the end of the low-pressure piston stroke.

The high-pressure cylinder has been receiving a fresh charge of high-pressure steam on the opposite side of the piston in the meanwhile, and cutting off at the same point, its expansion and terminal pressure will be the same as before, but the receiver this time will contain steam at the pressure present at the time of the previous high-pressure exhaust closure, or 24.39 absolute, as against 15 lb., or atmospheric pressure, assumed at first, so that the receiver pressure at the beginning of the second low-pressure stroke will be 34.20 lb., and at cutoff 28.93, and the end of the stroke 12.40, and in the high-pressure cylinder at its exhaust closure 30.71 compressed up to 122.84 at the end of the return stroke. The pressures at these points for succeeding strokes, carried out until the receiver pressure becomes practically stationary, are shown in the table.

STEAM PRESSURE AT VARIOUS POINTS OF THE STROKE

	Beginning of Low-Pressure Stroke	Low-Pressure Cutoff	Low-Pressure Terminal	High-Pressure Closure	High-Pressure Compression
(1)	27.16	22.98	9.85	24.39	97.56
(2)	34.20	28.93	12.40	30.71	122.84
(3)	38.94	34.27	14.69	34.97	139.98
(4)	42.14	35.65	15.28	37.83	151.32
(5)	44.28	37.47	16.06	39.76	159.04
(6)	45.72	38.69	16.58	41.06	164.24
(7)	46.70	39.52	16.94	41.94	67.76
(8)	47.36	40.08	17.18	42.53	170.12
(9)	47.81	40.45	17.33	42.93	171.72
(10)	48.11	40.70	17.44	43.20	172.80
(11)	48.31	40.87	17.52	43.38	173.52
(12)	48.45	40.99	17.57	43.50	174.00
(13)	48.54	41.07	17.60	43.58	174.34
(14)	48.59	41.12	17.62	43.63	174.52
(15)	48.63	41.15	17.63	43.67	174.68
(16)	48.66	41.17	17.64	43.69	174.76
(17)	48.67	41.18	17.65	43.71	174.84
(18)	48.69	41.20	17.66	43.72	174.88
(19)	48.70	41.205	17.661	43.73	174.92
(20)	48.71	41.21	17.661	43.736	174.94
(21)	48.712	41.217	17.662	43.7406	174.96
(22)	48.714	41.22	17.665	43.743	174.97
(23)	48.716	41.221	17.666	43.745	174.98
(24)	48.718	41.222	17.667	43.7466	174.986

It will be observed that the pressures all gradually increase except the high-pressure (forward) stroke, which of course remains the same throughout. If, therefore, the calculation is carried forward for a number of strokes, as given in the table, the pressure conditions for the other events will presently become stationary; that is, the receiver pressure will become fixed, with only slight pulsations of a pound or two. The volume of the receiver on a tandem-compound engine is seldom greater than the necessary connecting pipe and in any case does not affect the pressure except to reduce pulsation. It is not necessary, however, to follow the calculation step by step as the engine is started up. This was done in the foregoing, as a matter of interest that the operating man can observe for himself any day in starting up, by watching the gradual building up of the receiver pressure. The designer can do what the operator may also do; namely, put steam of any desired pressure into the receiver to start with, then calculate or watch the pressure change increase or diminish, depending on the amount and direction his "guess" is off, and the number of computations will not be great. It will be seen that some changes in valve dimensions or setting will be necessary in the case given, since the high-pressure compression is too high. If operating condensing the low-pressure terminal pressure is too high, but if the engine is exhausting into the atmosphere or a low-pressure heating system at about 2 lb. gage pressure, this feature would be about right. To bring the compression pressure just up to and not above that of the initial steam (140 absolute) in a space of 150 cu.in. (the clearance), it must be 70 lb. at $\frac{9}{10}$ stroke in 300 cu.in. (double the space) and 46⅔ lb. at $\frac{8}{10}$ stroke, so that it may be seen by inspection of the table of pressures that exhaust closure in the high-pressure cylinder should be about $\frac{8}{10}$ stroke.

The whole problem must be worked out carefully for each case, for if the engine is designed to operate condensing, the low-pressure cutoff must be earlier or the receiver pressure considerably lower to get the expansion or terminal pressure in the low-pressure cylinder reasonably near the vacuum maintained in the condenser. If, however, the low-pressure cutoff is set earlier (the low-pressure cylinder taking less steam) the receiver pressure will naturally increase, defeating the object of the early cutoff by admitting steam at a higher pressure for the shorter period offsetting the early cutoff. The high-pressure cutoff may be shortened so there will be less steam thrown into the receiver, but less power will be developed.

Effect of Cutoff on Receiver Pressure

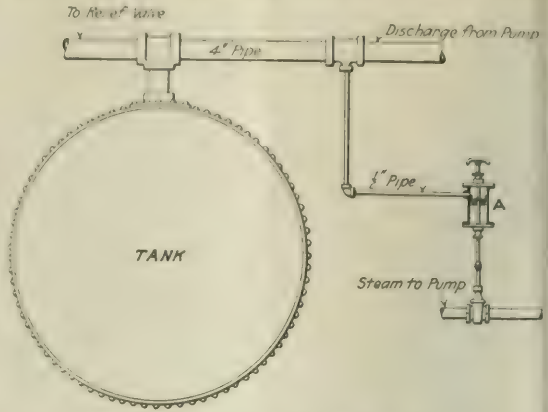
The changes in receiver pressure produced by a change of cutoff as affected by an automatic governor in control of both valves and also when only the high-pressure cutoff is changed, are as follows: In the latter case it is obvious that the receiver pressure will increase with a late high-pressure cutoff, with the low-pressure point fixed, but when both are changed the resultant receiver pressure may be higher, lower, or remain the same, depending on the relative points of cutoff and the original proportion or capacity of the cylinders. Suppose, for example, the capacity of the low-pressure cylinder was double that of the one given; then with both valves cutting off the same as before, the receiver pressure would obviously be proportionately lower. When both are changed by the governor, the receiver pressure may be increased, diminished or remain the same, depending on the relative point of cutoff of the two valves, while the amount or rapidity of the change (in receiver pressure) will depend on the relative size of the two cylinders. For example, in the case worked out both valves cut off at the same point ($\frac{4}{10}$ stroke), and if both are shifted to cut off at any other point the proportion will remain the same (except for the slight difference in clearance volume) and the receiver pressure will remain practically the same for any cutoff. This also holds true for any other relative cylinder proportions when the receiver pressure is once established. If, however, the valves are set differently, so that the high-pressure valve cuts off earlier than the low-pressure, the receiver pressure will not only be lower than in the example but it will change as the cutoff to both cylinders is varied by the governor. The shorter the cutoff the lower the receiver pressure will be, and as the cutoff lengthens the receiver pressure will increase. The reverse is therefore true if the high-pressure cutoff is made later than the low-pressure cutoff, and the greater the difference in point of cut off and in the cylinder ratios the greater the variation will be in each case.

Confining the changes to such valve adjustments as are possible with a Corliss-type valve gear, it will soon develop that the limitations are narrow, for as already stated, in order to get a reasonably low terminal pressure at the low-pressure exhaust valve opening, the cutoff must be early or the receiver pressure low. To get less steam into the receiver the high-pressure cutoff may be made early, but the power of the engine will be cut down. In short the possible number of expansions is determined by the point of cutoff in each cylinder and the relative capacity of the cylinders, so that the range of power economically developed by an engine of certain proportions is limited. It should be borne in mind that the calculation of the ratio of expansion must terminate with the low-pressure exhaust opening and not be carried beyond, to the back-pressure line, as is often erroneously done. Useful work by the steam against the piston stops when the exhaust valve opens, and the drop from the pressure at exhaust opening to that of the terminal or back pressure is lost energy. It is true, of course, that the back pressure should always be kept as low as possible in the interest of economy and greater power in the engine, but that is "another story."

The drop in pressure between the high-pressure exhaust opening and the receiver pressure does not represent a loss in the same way, however, for the drop in pressure is represented in a proportionate amount of work done on the escaping steam, producing heat. The steam in the receiver is of better quality (it may be dry saturated or slightly superheated) by reason of this drop in pressure without doing work. A drop in pressure between the final exhaust opening and the back-pressure line if the heat in the exhaust is not utilized in some other way, is wasted, and if operating condensing it is not only lost but is detrimental in putting heat into the exhaust to be got rid of in the condenser.

Home-Made Automatic Pump Stop Valve

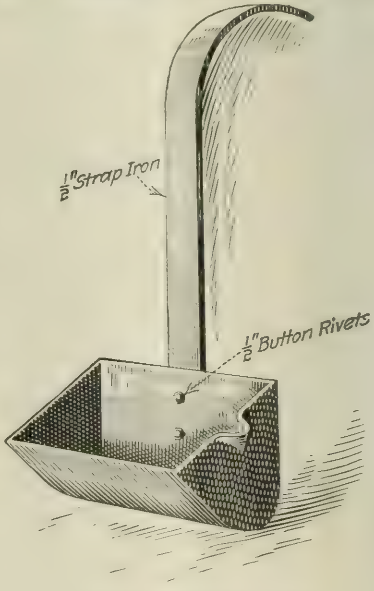
In a certain instance water was pumped into a closed iron tank. Help was scarce and the relief valve would occasionally be open for a considerable time before someone came along and shut off the steam supply to the pump. Finally, the stop device shown herewith was made. It consisted of two stuffing-boxes which were attached to the ends of an old 3-in. diameter pump cylinder taken from an iron hand pump. A ½-in. hole was drilled and tapped in the side of the cylinder for a pipe, which was connected to the pump discharge pipe. The cup leather of the old plunger was used with an iron washer behind it. A ⅜-in. rod passes through all and is fastened to the stem of a lift gate valve, a handle being fitted to the top of the rod. The whole is shown in the illustration. To start the pump the handle is raised; this admits steam to the pump cylinder, and the friction of the packing in the stuffing-boxes holds the valve in an open position. When the tank is filled, the pressure rises and, backing down through the ½-in. pipe, forces the cup piston in the cylinder down, thus closing the steam valve. The relief valve was set to open at 10 lb. pressure.



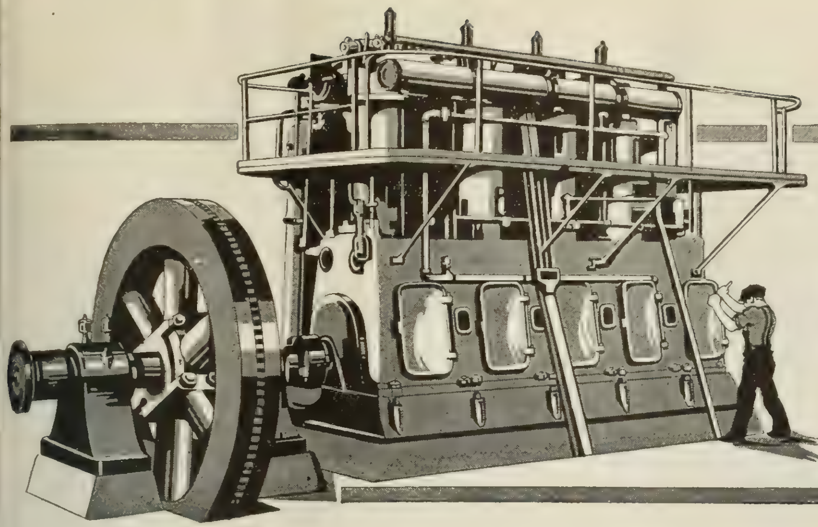
PIPING AND VALVE CONTROL

Simple Pouring Ladle

An easily constructed, serviceable grease or molten-metal ladle, says *Engineering and Mining Journal*, may be easily made from an old elevator bucket of the proper size by fastening thereon a handle of strap iron shaped to suit the requirements or the fancy of the user. As shown in the illustration, two ½-in. button rivets hold the handle securely in position in the center of the cup. If desired, a lip may be shaped on one end of the cup for ease in pouring.



A HANDY POURING LADLE



Talks on DIESEL Engines

by L. H. Morrison

II—Egan gives some pointers about the work of setting and lining up a second-hand Diesel engine, and explains how to take up wear in the crankshaft bearings.

THE hour set for the first regular meeting of the Diesel-engine study class found the entire force of the plant gathered around a long table that Egan had managed to obtain from the stockroom.

"I'm glad to see that we're all here," J. R. began. "It shows that we want to learn—all we need is the opportunity."

He turned to the day watch engineer, who was seated at the same side of the table.

"By the way, Kelly, the Runner Refining Co. asked me to let them have a man to set up an American Diesel they've bought second-hand. I told them I'd send you over in the morning. Are you ready to tackle the job?"

"Sure," was Kelly's quick come-back. "They should do the worrying. But there's one thing I'd like to know before I go. How do you line up the mainshaft?"

"I thought you'd ask that question," said the chief. "So I fixed up a few sketches, showing how we erected that old Diesel over there in the corner. You can probably improve on the method, but it will give you the idea.

"This sketch, which we will call Fig. 1, shows an end view of the engine with the cylinders in place. The top surface of the frame is planed to receive the cylinders, of which there are three.

"Now, the first thing to do is to get the frame on the foundation. You'll probably find that the foundation bolts are fixed at their lower ends and project above the foundation some six inches. If the frame is bolted on to skids, move it to the foundation, jack it up to let it clear the tops of the bolts, and unbolt the skids. Then crib it up with timbers and move it onto the foundation. Next, jack it up with jacks set in recesses in the foundation at the four corners, as in Fig. 2, remove the timbers, and lower the frame to the foundation. But don't forget to put about a dozen iron wedges under the frame, around the edges. Some erectors use wooden wedges, but these are likely to split in driving. Leave the iron wedges in place after the engine is lined up, for they come in mighty handy if the frame ever settles."

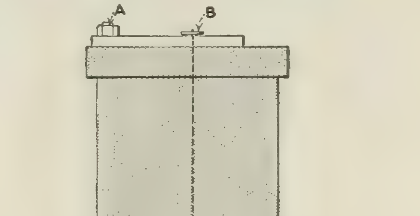


FIG. 1. LINING UP CYLINDER AND CRANKSHAFT

"What's the best way to level up the frame?" someone asked.

"Since the top surface of the frame is planed, put a spirit level on it and wedge up the low corners until the frame is level. Then run in grouting and let it set for a couple of days before you put on the cylinder castings."

"What's the best kind of grouting, Mr. Egan?" It was Woods who asked the question. "When we put in the hot-ball engine at the mill, we used sulphur."

"Melted sulphur used to be the common grouting material," J. R. answered, "but of late years most erecting men use neat cement. That's what I would use." He turned again to Kelly. "I'd advise you to see that the grouting is well troweled under the frame," he said. "Afterward, fill around the oil pan with cement to make a neat-looking finish."

Kelly was sitting on the edge of his chair, taking in all that was said. Egan continued:

"When the frame is set and bedded in, the cylinders can be put in place and bolted fast. This is not difficult, but be sure you draw up on the studs with the same tension. At this stage, Kelly, you have reached the point where you say you feel dubious.

"Now, there are four bearings—one at each end of the frame and one between each pair of cranks—which must be put in line, and their center line must square with the three plumb-lines let fall through the centers of the three cylinders.

"From a piece of hardwood 1 in. thick cut three strips and shape them to the dimensions shown in Fig. 3. Slip the large end over one of the cylinder studs and hold it in place by a nut, as at *A*, Fig. 1. Move the free end until the slot is over the center of the cylinder. Cut three thin metal disks about 1½ in. in diameter and punch each to receive a plumb-line. Drop the plumb-line through the cylinder, pass the upper end up through the slot in the wooden arm and fasten it to the metal disk *B*. The disk can then be shifted so as to center the plumb-line in the upper end of the cylinder. Do this with each cylinder. Use fine piano wire for the line and see that the bob is heavy and that it hangs well below the bottom of the bearing.

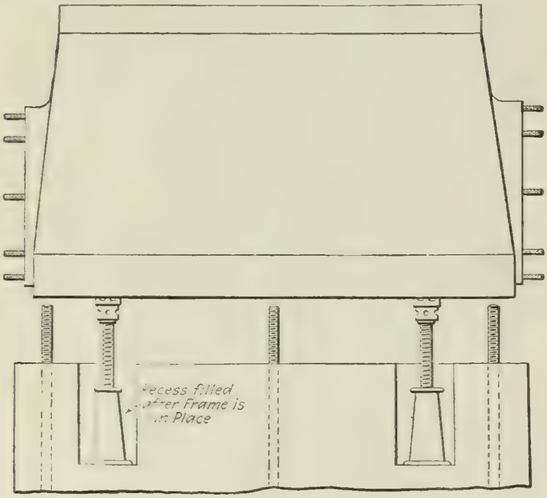


FIG. 2. LOWERING FRAME ON FOUNDATION

"If the engines were new, I'd suggest that you measure the cylinders at the lower ends to see if the plumb-lines were central at those points. If they weren't, you'd have to raise the cylinders and scrape the frame till the cylinder flanges could seat properly. But as the engines are old, the cylinders are doubtless worn and so you need to center the plumb-lines only at the top. You will probably find the plumb-lines will be in line. In case the center one is a trifle off, loosen up the flange bolts and move the cylinder the necessary amount. This will be less than a sixty-fourth of an inch, and even though the bolt holes are reamed to size, a few blows with a copper mallet and sledge will do the work."

"But how am I goin' to square up the shaft with the three plumb-lines?" Kelly demanded.

Egan hesitated a moment before he replied. "If it wasn't of benefit to the rest of the boys, too, I'd be inclined to make you figure it out for yourself," he said, laughing. "On some engines there are gage holes at the ends of the frame, but these engines may not have them. So you'd better make two more hardwood or strap-iron strips and bolt them to the opposite ends of the frame, as shown at *C*, Fig. 1. Set them so that the slotted ends are opposite the center line of the mainshaft bearings and stretch a length of piano wire between them, using disks as shown at *D*.

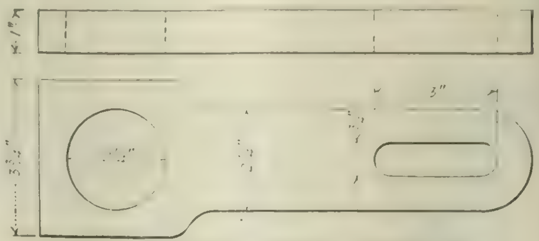


FIG. 3. STRIP FOR HOLDING PLUMB-LINE

"Now move the disks until the horizontal wire just touches the three plumb-lines, and level it at the same time with the spirit level. Caliper the four bearings and shift them until the horizontal wire is central in all of them. These bearings have wedge adjustments for height, and you'd better line them up with the wedges at their lowest points.

"Before you put the crankshaft in place, lay a piece of $\frac{1}{16}$-in. lead wire lengthwise along the bottom of each bearing. Then lower the shaft into the bearings and let it rest there. Next, raise it, take out each flattened wire and measure its thickness, which should be the same at all points. If it isn't, the shaft does not bear the full length of each box and it will be up to you to scrape the bearing to a perfect seat."

Woods interrupted with a question. "Why do those old Diesels have wedge adjustments on the main bearings while the new vertical engines here in the plant have no adjustments?"

"The first gas engines had nonadjustable bearings," explained the chief, "and there was trouble from damaged boxings and broken crankshafts. This was blamed on the bearings wearing out of line, which was probably true; but the remedy would have been larger bearing surfaces. However, the idea of using wedge adjustments on vertical engines was adopted and was followed by the first builders of Diesel engines. Of late years, builders have gone back to the wedgeless type."

"Which do you think's the best?"

"In vertical engines, the wedgeless," J. R. declared. "For instance, take the engines Kelly is to set up. I've no doubt he'll adjust the bearings to perfect alignment. But remember this—the outside bearings carry the weight of the flywheels as well as their share of the pressure load, and they will wear faster than the inner bearings. This difference has got to be taken up sooner or later. If the engineer is a cheap man, who has no idea of how much care must be used, the result will probably be a bent shaft.

"On the other hand, if no wedges are used, the work of adjusting for wear requires a good man, and an ordinary operator won't try it. The up-to-date builder scrapes his bearing housings to a test bar or shaft, and when this is done, all the lower bearings must naturally be of the same thickness. So it is only necessary to measure with a micrometer to find the wear on each bearing. To allow for this wear, sheets of copper or special laminated shims are placed between the housing and the bearing shell, and at the same time shims are removed from between the halves of the bearing to offset any play between shaft and shell. A good plan that I've followed here is to make a table of all the bearing-shell thicknesses. Then you're safe, even if the housings haven't been scraped."

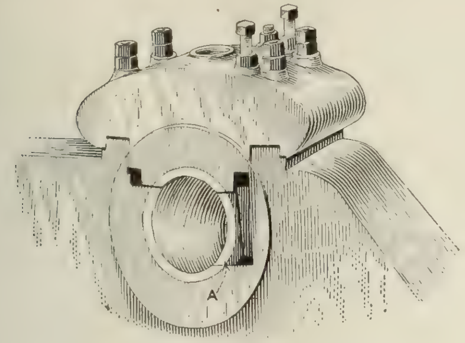


FIG. 4. MAIN BEARING WITH ADJUSTABLE FRONT QUARTER-BOX

"Chief, you said the outside bearings wore faster than the inside ones. Now, if there weren't any wedges, it seems to me you'd have to raise the shaft often to shim up those outside bearings," said Kelly.

"If all the bearings were the same length, your argument would be good. But on our four-cylinder 500-hp. engine the bearing on the side next the flywheel is about a third longer than the other ones. Also, the flywheel and the generator rotor are so located on the shaft extensions that most of their weight comes on the outboard bearing. On our other 500-hp. engine the shaft is of two-piece construction, also, but the bearing scheme is different. The entire weight of flywheel and generator rotor is carried by the two independent bearings. The reason for this construction is that the flywheel weight is constant while the pressure due to the explosions varies during each cycle. If the effect of the flywheel weight is confined to two independent bearings, the main bearing will wear evenly, and the outer bearings can be constructed so as to wear at the same rate, or to be adjusted easily if they don't."

"The people that build horizontal Diesels don't agree with you," spoke up Woods, who never left a subject until it was exhausted.

"That's a horse of a different color," laughed Egan. "The objection to the adjustable bearing doesn't apply to a horizontal engine. In fact, there is much in its favor. The wear in a horizontal engine comes on the front side of the bearing, which I have marked *A* in Fig. 4, and some form of adjustment is necessary to take up this wear. At certain points in the cycle the piston pressure becomes zero and the only bearing pressure is that due to the weight of shaft and flywheel, which acts downward. The shaft has a tendency to shift in the bearing at the point where the pressure changes, and if a two-piece bearing is used the operator will be kept busy shimming up. With wedge adjustment, the least wear in the quarter-box can be taken up.

"You'll notice that the rear quarter-box in Fig. 4 is not fitted with wedge adjustment. In some engines the rear quarter-box is cast with the bottom shell, on the theory that since no pressure is exerted on the rear quarter it will have no wear. This is true enough, but some method of adjustment is desirable. For instance, if the fuel oil varies and the compression pressure is to be changed, it can be done by means of these quarter-box wedges—moving the shaft inward toward the cylinder so as to alter the volume of the compression space; but it must be remembered that all bearing wear is taken up by means of the front wedge—that is, the one farthest from the cylinder.

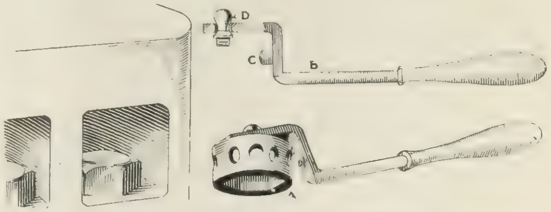
"If the engine has an outboard bearing, it would be dangerous for an inexperienced man to try to alter the compression by adjusting the front quarter-box. Of course, on all but the older engines the way to alter compression is by means of shims at the big end of the connecting-rod. The great advantage of having both quarter-boxes adjustable is the ease of taking up any and all wear."

J. R. pulled out his watch, glanced at it, and began to collect his sketches.

"It's time to quit," he announced. "Next Tuesday night we'll hear from Kelly as to how he's coming on with his erecting job."

Ratchet Wrench for Close Quarters

An engineer is often confronted with the task of loosening or taking up nuts located in restricted openings, as shown in the accompanying illustration, where they are almost inaccessible with a wrench of any ordinary type. To overcome this difficulty, says J. A. Lucas in *Coal Age*, I made the ratchet wrench shown to the right in the illustration. The hexagon part *A* of the wrench is made by forging a piece of suitable steel pipe around the nut and drilling holes on its circumference. The handle *B* is provided with a pin *C*, which fits the holes in the wrench body. It is fastened to the upper part of the wrench by means of a pin formed as shown at *D*. The operation of this wrench is self-explanatory.



DETAILS OF A RATCHET WRENCH

Economies in the Utilization of Electrical Energy in the Plant

By WILLIAM FREDERICK

Presents the importance of stopping the multitude of apparently insignificant leaks which are apt to develop in a plant, particularly under the stress of rapid expansion, in order to promote the conservation of fuel. Points out a number of sources of possible loss throughout the plant and suggests means of correcting or avoiding them.

THE need for conserving fuel, particularly coal, is too well known to require reiteration. What does need to have emphasis placed upon it, however, is the fact that fuel conservation is not confined to its economical use under the boiler nor to the most approved methods of using the steam produced. So much of the mechanical power utilized by plants of all kinds is transmitted from the steam engine or turbine to its point of application by means of electricity that a consideration of the economies which can be introduced in its transfer and use are of great importance. They will often be found to be small ones; in fact, it is the small leak which is apt to go on unnoticed the longest. Even when we are aware of its presence, we are prone to ignore it in the press of more urgent matters. The importance of the small saving cannot, however, be overestimated. We have recently had splendid illustrations of the magic possibilities of accumulating huge totals through a multitude of insignificant contributions. The same holds true of small savings in power; the total of many will appreciably reduce the demand on the coal pile, although each one of itself may appear to be too minute to matter. It is therefore the duty of the electrical staff of the plant to ferret out every such loss and to apply the remedy required.

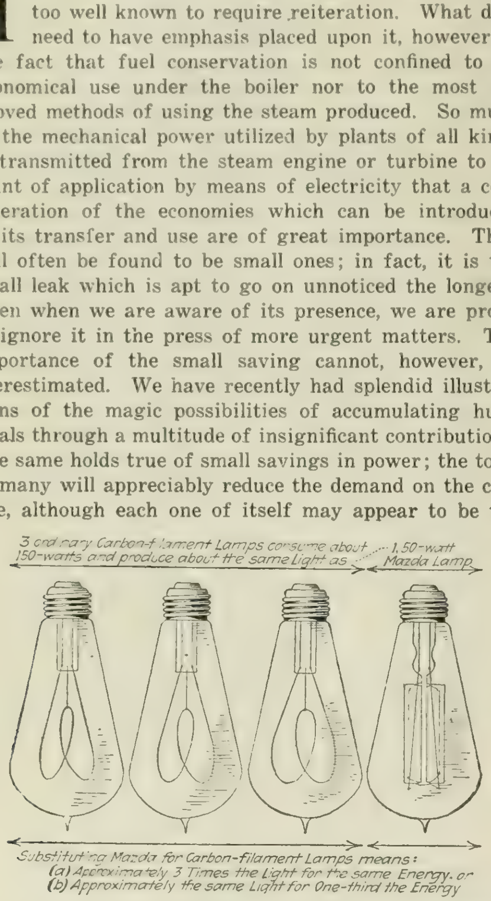

3 ordinary Carbon-filament Lamps consume about 150-watts and produce about the same Light as
1, 50-watt Mazda Lamp
Substituting Mazda for Carbon-filament Lamps means:
(a) Approximately 3 Times the Light for the same Energy, or
(b) Approximately the same Light for One-third the Energy

FIG. 1. GRAPHICAL COMPARISON OF THE EFFICIENCY OF OLD AND MODERN LAMPS FOR SHOP USE

The problem in electrical power saving begins at the generator. Fortunately, apparatus of this kind has reached a high degree of efficiency and is therefore not a cause for concern. What should, however, be considered is the size of the generating unit compared with the demand upon it. The use of a unit that is too large or too small for the load served and that, in consequence, operates at an excessively low efficiency for long intervals of time, is as surely a drain upon the fuel resources as if the current were being wasted in useless illumination or useless plant operation. However, this a matter of first installation and in a well-designed power plant the conditions have been met as efficiently as possible, and even in those cases that leave something to be desired, it might be a matter of great expense to correct the situation and would, perhaps, not be justified from an economic standpoint unless the conditions were abnormal.

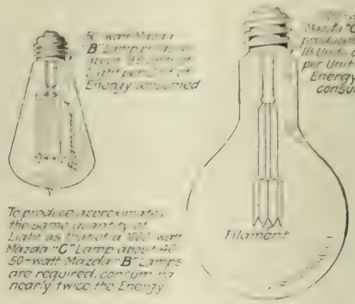

50-watt Mazda "B" Lamp produces about [illegible] Units of Light per Unit of Energy consumed
[illegible]-watt Mazda "C" Lamp produces about 18 Units of Light per Unit of Energy consumed
To produce approximately the same quantity of Light as that of a [illegible]-watt Mazda "C" Lamp about [illegible] 50-watt Mazda "B" Lamps are required, consuming nearly twice the Energy
Filament

FIG. 2 COMPARATIVE EFFICIENCY OF SMALL AND LARGE MAZDA LAMPS

Beginning at the switchboard, however, many economies can be instituted at but slight expense and in many cases without expense at all. One source of loss that is frequently lost sight of is that which occurs in the service wires themselves. We become so used to the thought that feed wires have an inappreciable resistance that it is difficult to realize the magnitude of the loss that occurs in them, particularly when they are of considerable length and when an increasingly great load is imposed upon them through increased plant production. Too often the size of the wire is determined solely by the underwriters' requirements without reference to the loss that will occur in it. When lights are served from the same mains as motors such a condition is not so likely to occur, or to endure if it does, since the drop in voltage and the flickering due to changes in voltage would call for correction of it. When motors alone are served, however, there may be a very material reduction in voltage without any noticeable indication thereof in their behavior. The relation between the cost of installing additional carrying capacity and the saving effected thereby is of course the controlling factor in deciding how far to cut down line losses, but if unfavorable conditions are suspected, they should at least be made the subject of investigation, and if they are found to exist their presence should be made known.

Being assured of the economical distribution of electrical energy the next problem to be considered is its economical use. Broadly, there are two uses to which electricity is put; namely, power and light. The former is furnished by motors and the latter by lamps. We therefore have to consider these two general classes of apparatus and their application to the existing conditions.

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*Credit is due C. E. Clewell for several suggestions incorporated herein.

Motors are of various types, and of course the first duty is to determine that the one used is of the correct kind and also of the proper size. In addition to this the starting and regulating devices should receive careful attention. The applications of motors in the plant may be divided into two classes—individual drive and collective drive. In the former case the motor drives a single piece of apparatus, and in the latter it is connected to a lineshaft or other such means of supplying power to a number of different loads. The individual drive is theoretically the preferable one, but of course many elements enter into the question from a practical view. These are the general aspects of the motor situation, and a survey of them should be made from time to time for the purpose of making recommendations looking to the more economical use of the power available. There is such a diversity of applications and there are so many individual problems involved that in the very nature of things no specific suggestions can be made in reference to them. However, there are a number of precautions which are of general application to all kinds of motor drive, some of which are set forth in what follows.

Among the losses in motors are friction of bearings and brushes. Care should be exercised in keeping this loss as small as possible. Bearings should be given careful attention and brush spring pressure should be reduced to the lowest point consistent with satisfactory operation of the machine. In the case of belt drives there should be a minimum of slip, geared drives should be kept well lubricated and badly worn gears replaced; in direct drives the alignment should be given attention. When not being used, motors should be shut down and not be allowed to run idle. To encourage economy in this direction, it is the part of wisdom to install control apparatus at convenient locations. Two objects are gained thereby—the operator is induced to practice economy, and a saving of his time in reaching the point of control is effected. However, it is not economical to shut down a large motor for only a few moments. The energy and time used in starting it again will more than counterbalance the saving during the interval of shutdown.

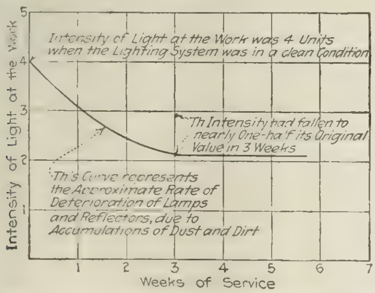

FIG. 3. CURVE SHOWING DETERIORATION WHICH MAY OCCUR IN LIGHTING EQUIPMENT, DUE TO DUST AND DIRT ACCUMULATIONS IN THE SHOP

Wasteful methods of speed control should be eliminated. For example, for direct-current shunt-motor operation requiring adjustable speed, interpole machines should be used, the speed control of which can be accomplished by means of field-current regulation, in preference to the old type of straight shunt motor requiring resistance in the armature circuit, which is a method very wasteful of energy, especially when a wide range of speed regulation is necessary. Moreover, the superior speed regulation of the interpole motor at each step of its speed leaves little excuse for the retention of the old type of machine for adjustable-speed service.

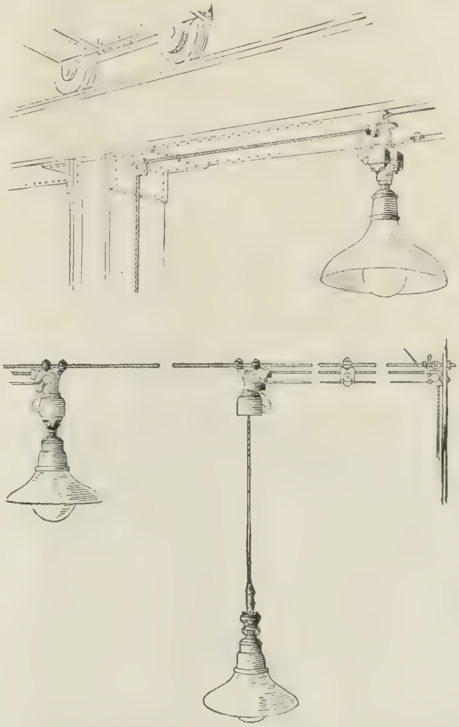

FIG. 4. ARRANGEMENT AND OPERATION OF A THOMSON DISCONNECTING HANGER ADAPTED FOR SHOP USE

In the case of alternating-current motors requiring frequent starting, it is preferable to use a transformer type of starter rather than a resistance type, since the loss in the latter far exceeds that in the former. The manner of starting motors can also be made the subject of economy, especially in large sizes, and it is an argument for the installation of automatic starters wherever possible. Dynamic braking is another means of economy which should be employed where conditions permit its use.

The other use to which electrical energy is put—namely, lighting—offers even a wider field for economy on the part of the individual than is usual with power applications. While the amount of energy involved is small in comparison with power demands, the multiplicity of occasions on which savings can be effected is such that the total will compare very favorably with the power economies. For example, no one would consider allowing a 10-hp. motor to run idle for hours at a time, and yet less power would be wasted thereby than by allowing twenty 50-watt lamps to burn uselessly.

A regard for economy in this direction can be fostered by placing the controlling switches in readily accessible locations, as in the case of motor-controlling devices

Moreover, if group lighting is in use, there should be only a limited number of lamps on each switch, in order that the lighting may always be subdivided to meet the requirements. Thus, a room of some depth may receive sufficient daylight under the normal condition, but may require artificial illumination in the parts farthest removed from windows when the day is dull. It should be possible to turn on lamps in this section without at the same time turning on those in the sections that remain well lighted from the outside.

The type of lamp used, the style of reflector and the maintenance of both the lamp and its reflector are matters of particular interest. Bound up with the efficiency of the lighting system is its effect upon production. Better lighting usually means greater production, less wasted effort, less irritation to nerves. Probably few things lead to greater inefficiency than the physical discomforts of lack of proper heating and lighting, and the nervous strain due to the latter cause is none the less real because it is generally not apparent. By better lighting is not necessarily meant more light. Oftentimes a reduction in illumination is actually desirable. The apparent inefficiency of indirect lighting systems is in reality a gain, in that the rate of production is stimulated by the greater comfort of proper illumination. We do not primarily wish to obtain the greatest candlepower per square foot of floor surface for the consumption of a given quantity of coal; what we desire is the greatest output of product for that amount of coal. Thus, while it seems irrational at first sight to develop a lamp of high efficiency and then deliberately to divert its lighting power to such an extent that the final illumination obtained is only a fraction of that utilized, the results will be found to justify the means.

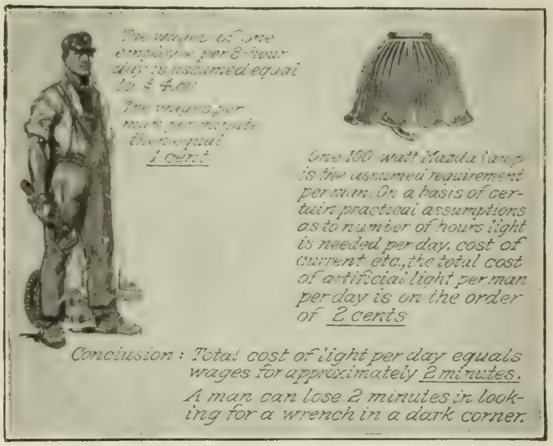
The wages of one employee per 8-hour day is assumed equal to $4.00
The wages per man per minute then equal 1 cent
One 100 watt Mazda lamp is the assumed requirement per man. On a basis of certain practical assumptions as to number of hours light is needed per day, cost of current etc., the total cost of artificial light per man per day is on the order of 2 cents
Conclusion: Total cost of light per day equals wages for approximately 2 minutes.
A man can lose 2 minutes in looking for a wrench in a dark corner.

FIG. 5. COMPARISON BETWEEN LIGHTING COSTS AND LABOR IN THE AVERAGE SHOP

While the laying out of a comprehensive system of lighting may require the services of an illumination engineer just as the laying out of the power installation would require those of a power engineer, yet the man about the plant can inaugurate many economies on his own initiative, and can, moreover, add greatly to the efficiency of any existing installation by systematic inspection and maintenance of it.

The first point to be observed is that only high-efficiency lamps should be used. There is today practically no excuse for the use of carbon filament lamps on circuits that utilize coal-made current. A 50-watt metallic filament lamp using 1.1 watts per candlepower gives an illumination of about 45 cp., in comparison with which a 16-cp. carbon filament lamp at 3.1 watts per candlepower requires an input of about 50 watts. That is, for a consumption of the same amount of energy we get about three times the illumination from the metallic filament, or "Mazda," lamp, that we do from the carbon filament one. This can be shown very strikingly by such a comparison as that made in Fig. 1, in which the ratio is shown by the relative numbers of lamps used.

Next in importance to the use of high-efficiency lamps, is the selection of the correct size of the unit, and following that the best type of reflector or shade to be used. For individual use great brilliancy is objectionable and a 50-watt lamp is more than ample. For general lighting the size of lamps will be determined by the distribution required and the height of ceiling. Conditions being suitable, it is preferable to use one large unit in place of several smaller ones, since the efficiency of the large gas-filled lamps far exceeds that of the small Mazda lamp. Thus, one 1000-watt lamp will produce approximately the same illumination as forty 50-watt lamps using twice as much energy, as illustrated in Fig. 2. However, a lamp of this size can be used only under exceptional circumstances and should not be employed without a thorough understanding of the principles involved. On the other hand, it is a matter of comparative simplicity to select a shade or reflector most suitable to the requirements. For general illumination glass shades can be used to advantage if their position does not expose them to breakage. The manufacturers of such shades issue detailed information regarding the direction given to the light from the lamp by the various types of shades, and the one to be selected is, of course, that which throws the light where it is most wanted.

There is slight object in installing a highly efficient lighting system if its upkeep is not a matter of constant care. Two things are to be observed in reference to it—lamps must be renewed when their useful life has been spent, and above all, lamps and reflectors must be kept clean. To emphasize the importance of this latter point reference is made to Fig. 3, which shows by means of a curve, the deterioration that took place in a lighting system within a period of a few weeks, due to failure to clean the lamps and fixtures. As will be seen, the illumination had decreased almost 50 per cent. at the end of three weeks, owing to this cause. It is, consequently, a matter of great importance to systematically look after the equipment, and to arrange it in such a manner that it can readily be reached.

Where lamps are situated at considerable heights, some such device as that illustrated in Fig. 4 should be used to make them accessible.

While it is desirable, in fact, necessary, to have sufficient light where light is required, there are many parts of a plant that require only a very small amount of general illumination and in which lavish lighting provision would be a waste. On the other hand, curtailment of illumination should not be carried to the other extreme. An operative's time is far more valuable than the equivalent of the light that he requires, and it is false economy to allow conditions that in any way interfere with the most profitable use of his time or labor. In Fig. 5 is presented a comparison showing that lighting provision per man in an average plant will be in the neighborhood of two cents per day, whereas his wages will amount to about one cent per minute. It would therefore require a loss of only about two minutes of his time to wipe out what could be saved by failing to provide him with adequate illumination.

Each plant will present its own problems, but in each one diligent search will generally unearth many sources of slight waste. In applying remedies, it is of course necessary to use judgment; the plant must produce more material for the same coal consumption or use less coal for the same production rate.

The Power Situation at the End of the War

By L. W. ALWYN-SCHMIDT

The author summarizes the power situation that has resulted from the upheaval of war and points to a greatly increased use of power in industry in the future.

MODERN industrial enterprise cannot exist without power. Considering this fact it seems that our existing means of providing this essential adjunct to all industrial production are pitifully small. There are today only three recognized creators of industrial power—fuel, water and wind—not a very imposing number to fall back upon, especially as little use is made of the third.

The war has overthrown our complacency. It has shown us that the principles of our power economy are faulty, not to say wrong, and that the system under which we are working is not reliable and will break down if exposed to any great stress. We had an example of this when many of our national industries had to shut down for a series of Mondays because sufficient coal could not be provided to keep their boilers going. We had another example when a million automobiles were laid up for several Sundays because sufficient gasoline was not available.

DISTRIBUTION OF COAL TO POWER HOUSES

The distribution of coal from the mines to the power houses has not been solved satisfactorily. The problem today is the same as it was five years ago. Nevertheless, the war has taught not only the nations but also the individual power producer that coal is not absolutely reliable as a generator for industrial energy. The principal deficiency in the case of coal is its limitation in production. Coal is mined in comparatively few localities, and the necessity of bringing it to the places where it is consumed forms a permanent burden on the transportation facilities of the world. An interruption of these facilities threatens an immediate breakdown of industrial production. There are many countries that have very little coal of their own, or coal of very inferior quality, and that depend for the upkeep of their industrial life on the good will of other countries. Their industry may be completely strangled if these countries should decide to stop supplying coal. What is said here with reference to coal applies more or less to oil and coal gas also.

While the war has not provided a solution of the various problems created by the use of coal for power production, it has at least set many minds to work to find a way out of the present difficulty. Two proposals have been made. The first is to stop shipping coal for power production, to produce the power on the spot where the coal is found and to transmit the power. The second is to limit the use of coal as much as possible and to use other more convenient forms of power production, as, for instance, water and wind. As an immediate means of bringing relief a more economical use of coal has been advised.

The latter proposal may be considered here in the first place, not only because it has been applied with great success during the war, but also because conservation will be a considerable factor in after-war power production until more thorough changes in power production and conservation can be effected.

COAL-CONSERVATION WORK IN ITALY

The most thorough work with regard to coal conservation probably was done in Italy. The Italian industry has had to battle with the coal problem from the first days of the war, even before it had entered the struggle. The lignite produced in Italy is of small steam value and nearly all industrial fuel is imported. When it became clear that Italy would have to face a serious fuel crisis, the Italian government had a survey made of its power facilities with a view to establishing the number and character of boilers that would be available for power production, and what might be their efficiencies with different fuels. Especial attention was given to the question of burning native coal. Power engineers all over the country were advised to exercise great care in the use of coal and to avoid all waste of power. The result was that Italy obtained a greatly increased industrial production with a vastly decreased supply of imported coal. In France similar good results have been obtained.

IMPROVEMENTS IN ECONOMY LIKELY TO CONTINUE

There has possibly never so much been written on fuel conservation, power economy and similar subjects as during the last four years. American writings alone would fill a good-sized library. Each contribution to the solution of the great problem of how to get maximum power with the use of the smallest amount of coal has advanced us a step farther. Statistics show that many factories have reduced their coal consumption by more than 10 per cent. We may possibly relax in our vigilance, but it seems improbable that our improvements will be lost again. It is much more likely that improvements, once introduced, will continue. One of the results of the war will be that fewer railroad cars will be wasted in future and that less coal will be required by those establishments which will continue to burn coal.

The idea of centralizing the production of power in certain favored neighborhoods and distributing it to consumers has claimed wide attention in England. A British governmental committee of engineers has worked out a plan by which it is proposed to erect a series of large central stations in certain suitable cities and to connect these stations with substations in other cities for the distribution of power to the consumers. The principal producing stations will be interconnected in such a way as to guarantee a permanent supply of power to all consumers even if one of the stations should break down. The English plan provides for the use of coal only. The cities that have been elected for the localization of the principal stations are conveniently situated in proximity to coal fields, and coal, therefore, will be always available at cheap rates.

Centralizing the Production of Power in Germany and France

A similar proposal was made in Germany and in part at least was carried out during the war. The German plan, however, goes a step farther than the English, because it proposes not only the use of coal as a producer of the required electrical energy, but use will be made also of certain water powers. The scheme provides for a series of central stations in coal fields with hydro-electric stations on lakes and rivers, and the general idea seems to be to arrange the individual stations in triangles. Two hydro-electric stations always will have the support of one steam-generating station, the three supplementing one another. Finally, all the stations will be interconnected. Power from part of the new system is already being transmitted over distances which in some cases exceed a hundred miles.

A similar proposition has been made in France, and it is also intended to arrange on the coöperative plan the new central-station system which will replace the stations destroyed by the Germans. The present plan provides in the French northeastern coal fields a number of big power stations that will distribute power not only to the immediate neighborhood but most likely also to Paris.

Power Stations in the Coal Fields

The system of placing electric power stations in the coal fields, while it appeals to the imagination of the engineer, has certain economic disadvantages that in later years may lead to actual difficulties. One of these is that the electrical power produced in this way is unreasonably expensive in the immediate neighborhood of the central station. Experience has shown that large industrial enterprises in the vicinity of coal fields are not very good customers for central stations in the same districts for the simple reason that they can produce their own electric power cheaper than the central station will sell it.

The big industrial enterprises in proximity to the coal fields can obtain coal without straining unnecessarily the national means of transportation, and if they choose to make their own electrical energy, more of the central-station power will be left for distribution to the farther removed districts. But there is an economic limit to the distribution of coal-generated electrical energy. Eventually, a distance is reached at which distribution of energy either is impossible owing to technical reasons or becomes too expensive in comparison with other means of producing power. It may in such instances even be cheaper to ship coal than to transmit electrical energy.

World-Wide Increase in Application of Hydro Electric Power

The outstanding feature of power development during the war is the rapid expansion of the application of hydro-electric power all over the world. There is not a country that has not given attention to the question of how to make better use of its dormant water power by turning it into electrical energy. Norway, doubtless, has led the way in this respect. Thousands and thousands of horsepower have been harnessed during the last four years and this country has carried out a power scheme the foundations of which were laid before the war. Norway in this respect has been favored very much by the mountainous character of the country, the many waterfalls of which seem to supply what amounts to a practically inexhaustible supply of natural power.

Italy has been able to supplement its existing power supply by an increasing recourse to natural power derived principally from the waterfalls of the southern decline of the Alps and the Apennines. The Alps most likely will play a considerable part in the future by supplying Europe with electrical energy. Switzerland will soon be the owner of a large system of interconnected hydro-electric stations, efforts are being made to harness the waterfalls of the French Alps, and Germany has in operation several hydro-electric stations, all built during the war, which draw their power from rivers fed by the snow mountains of the Alps. Another important center for hydro-electric developments in Europe is the Pyrenees. Several new hydro-electric stations have been added to those existing during the war, and France as well as Spain has prepared a number of projects which will make use of the waters of this mountain range.

Hydro-Electric Power Development in South America and Australia

In South America there is a great awakening to the necessity of making better use of natural resources. Parts of South America, as Venezuela, Colombia, Peru and Chile, offer conditions for hydro-electric development as favorable as those existing in Norway. These conditions are being studied by the governments and financial interests with a view to making use of them in the near future, while a number of projects have already been taken in hand or have been completed during the war. In Australia great work has been done by completing the Great Lake development in Tasmania and the Lake Coleridge development in New Zealand. Both schemes were finished under great difficulties, but the assistance they have rendered to the industrial development of their respective countries in a trying time has repaid a hundredfold the expense and labor incurred in their completion.

Public ownership has made considerable progress during the war. This has been partly the result of earlier policies, but just as much that of existing conditions. In some cases the original promoters were not able to carry out the work and the government was compelled in the public interest to complete the task. In others necessity made imperative immediate construction which had to be carried out with public aid, as no private capital would undertake the work. Norway has used the opportunity to strengthen the power of public control over the natural resources of the country, and similar projects are now under consideration in other countries, including the United States.

Speaking in general terms it appears that the war has rather benefited the power industry. Its principal results so far are a tendency in the direction of greater centralization of power production, an increase in the use of water power for electrical development and an awakening of the national consciousness to the responsibility for the dormant natural-power resources in the possession of the nation. The war finally has taught us the great value of mechanical power as a preserver of human energy.

It is this final realization which will be the dominant factor in future power development. Having once recognized this inherent characteristic of mechanical power and its economic effectiveness, the world will not return to its pre-war methods of wasting human energy where it can be easily replaced by mechanical power. It also will not return to its pre-war practices of wasting power. The effect of all this will show soon in the general position taken by power users with reference to the methods employed in the production of power. The old-time engineer, the happy-go-lucky chief, will be a man of the past. He has not been driven out, but the hard time he has gone through has changed the man and his method. Factory owners and power users suddenly have come to the realization that their power supply is not a thing to be taken for granted, but that it is subject to the same economic laws as all other forms of industrial production and that it has to be handled efficiently if it is to produce efficient results.

There will be more power used in future than has been used in the past. Europe must replace by an increasing recourse to mechanical power the energy of many millions of men who were killed during the war. It also has to make up for the loss of efficiency in the crippled who will again take part in industrial production.

We in our own country will have to make use of additional power to keep our industrial production at a level that will enable us to compete with the cheaper European goods so that we may hold our present position in the world's markets.

Rejuvenating a Worn-Out Pump

By H. H. HUNNER*

A SINGLE-STAGE pump making 1750 r.p.m. and pumping 1290 gal. per min. on a 165-ft. head was found to lose its water once or twice in 24 hours whenever the power-line voltage fluctuated to a point low enough to cause it to drop in speed, and when running, the pump would pound with a continual end thrust. On examination it was found that the ring seats were worn away on both sides of the impeller and that the recess in the castings which accommodated the rings was gouged out on both sides, top and bottom. The sides of the casing next to the impeller were worn in places to a depth of over half an inch.

To repair the impeller, the ring seats were turned down to make a driving fit for two rings that had been previously made up. A ¾-in. section was cut from these rings, the ends were drawn up and welded, and, after having been driven to a tight fit on the new seats cut on the impeller, they were turned down to give a running fit for the standard rings, which made an impeller as good as new.

The repair of the castings required two barrels of charcoal, 40 ft. of 42-in. asbestos paper, 75 firebrick, 150 cu.ft. of oxygen and 12 carbic cakes. An air line was extended to the place where the castings were to be heated, and five feet of 1-in. pipe was used for a nozzle to produce forced draft. The castings were stood on end on the ground, propped up with firebrick and walled in on all sides with the firebrick placed about 18 in. away from the castings, the brick being laid with about ½-in. spaces end to end.

The brick wall was built up to the height of the castings, and the charcoal then dumped in between the brick and castings on a kindling-wood fire. The top of the castings and the charcoal was then covered with two thicknesses of asbestos paper, cut into 42-in. square sheets; the air, turned down to about 10-lb. pressure, was used to give the charcoal a good start, and the improvised furnace was left for three hours without artificial draft, after the charcoal had a start. On removing enough brick to reach the ring recesses, it was found that the castings were easily brought up to a welding heat on applying the torch for a few seconds.

Both castings were repaired on one side, and the brick wall was torn down, using forceps to handle the bricks. The castings were flopped, the charcoal was heaped around their base, and the bricks were built up to hold the charcoal in place. By covering the entire work with asbestos paper, the operator was able to work at close range without undue exposure to the heat. When the time arrived to fill in the last piece of casting, it had cooled too much to work without reheating. The supply of charcoal was exhausted, but pine wood was available, and the bricks were covered with sheet iron and the air nozzle was used again, and this combination secured a better heat in an hour's time than had been possible by means of the charcoal, which is not essential where air is available.

The operation was finished in about eight hours, and little hammer and chisel work was required to get a smooth job on the castings. At a moderate expense a new water end was provided, and a wait of six months for delivery on a unit that was absolutely essential was obviated.

The castings were covered with the asbestos paper after the job was finished and allowed to cool slowly for several hours.

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*Superintendent Onahmon Iron Co., Ironton, Minn., in *Engineering and Mining Journal*.

Coal-Handling Plant at Sewalls Point, Virginia*

New facilities of the Virginian Railway at the coal pier near Norfolk, Va. The plant also includes cars of 120 tons capacity and a long incline.

A DOUBLE car dumper, with pier cars of 120 tons capacity and an elevator to raise them to the top of the pier, have been added to the facilities of the coal pier of the Virginian Ry. at Sewalls Point, near Norfolk, Va. They supplement a single dumper, pier cars of 60 tons capacity and a barney incline from the dumper to the top of the pier, installed in 1909, when the pier was built, and increase the capacity of the plant from 1500 tons per hour to 3000. The operation of the pier is the same as before, the pier cars for both dumpers running out to the end of the pier by electric power on the outside track and returning down the inclined center track.

The double car dumper is the first built to overturn two ordinary road cars at a time. It is 94 ft. long between end posts. The car rails are carried on a movable platen which rests on rollers in the bottom of the cradle —or, in fact, two platens, end to end, one for each car. When the cars are on the dumper, the platens are moved laterally until the sides of the cars come securely against the side of the cradle for support. When the two cars are of about the same width, it is not necessary to uncouple them, but when they are of different widths the two parts of the platen can be operated separately. Eight clamps are operated independently by counterweights which travel in guides at the rear of the machine. They are so spaced that they engage various lengths of cars and are automatically adjustable to any height or width of standard railway car.

ROTATING MACHINERY TOP OF MAIN STRUCTURE

The machinery for rotating the cradle is located on top of the main structure, where it is free from dust and accessible for repairs. After the cars have been properly placed on the cradle, the rotating mechanism is started and the cradle with the cars is revolved until the cars are inverted to an angle of 20 deg. with the vertical. The clamps as well as the cradle are counterweighted, this facilitating the return of the cradle to its former position.

Coal dumped from two cars end to end is distributed over a maximum length of about 88 ft. This is much greater than could be gathered in the hopper of a transfer car, which in this case is about 51 ft. In order that all the coal from the road cars shall be properly discharged into the transfer cars without resort to a concentrating chute, which would at once result in an extreme drop of the coal, two steel apron conveyors are provided, each about 8 ft. wide and 34 ft. long, supported horizontally in a portal frame in front of the car dumper. A clear space of about 36 ft. is left between the conveyors, which form a portion of the bottom of a hopper into which the road cars are dumped. The longitudinal center of the conveyor is located directly over the center line of the transfer-car track. With this arrangement all the coal that falls on the conveyors is transferred horizontally and discharged into the transfer cars.

Two 275-hp. motors, designed to work on a direct current of 550 volts, operate the cradle working through four drums geared by three reductions of cut spur gears.

As the cradle is rotated the contents of the car is gradually discharged over the edge of the apron plate, into the receiving hopper which carries the conveyors. This hopper, for a distance of 36 ft., is open at the bottom, and the coal is discharged directly through it into the transfer cars. The conveyors are interlocked with the cradle, so that when the rotation starts the conveyor motor is also started, and the conveyors are in full operation when the first coal falls on them. They are both operated by one 80-hp. motor.

THE DISAPPEARING BARNEY

A disappearing barney, which on the return trip, when near the bottom of the incline, follows a low-level track into the barney pit so that cars can be let down by gravity from the load yard before the barney is in position, pushes the road cars up to the dumper. Both the barney and the dumper are operated from a cab at the incoming end of the dumper. All of the speeds and the motions of the dumper are regulated to produce a complete cycle in two minutes.

The dumper will handle at once two cars of 60 tons capacity, or one of the new 110-ton hopper cars of the Virginian, which weighs 160 tons when loaded.

Transfer cars of 120 tons capacity—just double that of those originally installed on the pier—take the coal from the dumper. These cars are mounted on two six-wheeled equalizer trucks, each of which is provided with a driving motor of 60-hp. capacity, geared for a speed of 12 miles per hour.

The trucks are spaced 50 ft. center to center under the car, the total over-all length of which is about 70 ft., the height 16 ft., and the width 12 ft. The body of the car forms a hopper divided into three compartments, each having a capacity of 40 tons, the three compartments having a combined length at the top of about 51 ft. Each of the compartments is provided with a double system of discharge gates at the bottom, through which the coal passes into the pockets to the pier. The gates of each compartment are separately operated by an air cylinder located in the end of the car.

DISCHARGE GATES ARRANGED IN PAIRS

The discharge gates of each compartment are arranged in pairs and hinged to the car body at the sides and in the center, in such a manner as to provide two openings 9 ft. long by 3 ft. 8 in. wide. The operating mechanism is so arranged that the gates are securely locked when closed, and they cannot fall open.

All operations are controlled from one end, although each end is inclosed. The power for operating the cars is supplied from an overhead catenary system. The combined weight of the car and its contents is about

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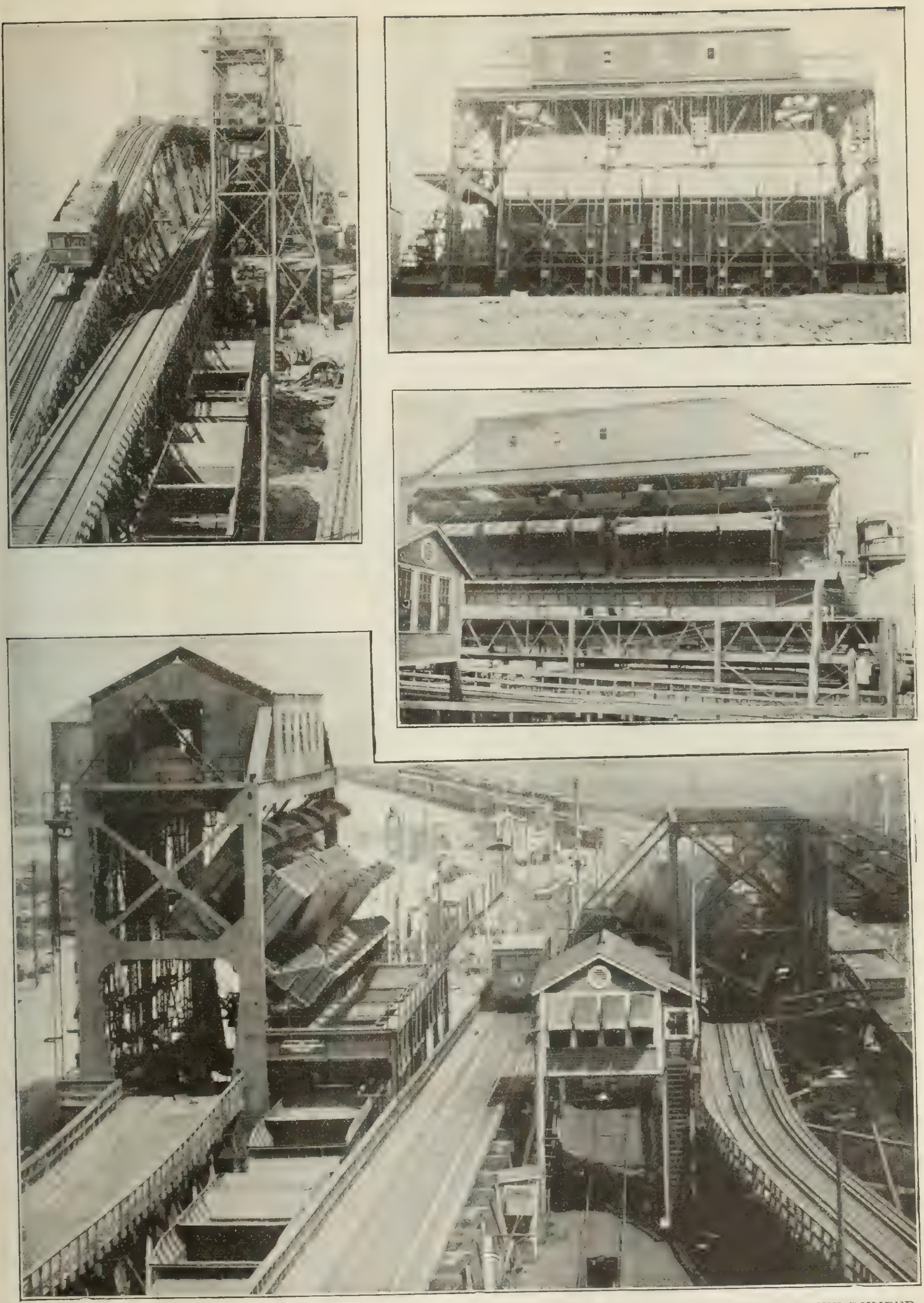
*From *Coal Age*



TWO GENERAL VIEWS SHOWING OLD AND NEW FACILITIES SIDE BY SIDE AND TWO VIEWS OF NEW DUMPER HANDLING TWO ORDINARY ROAD CARS AT ONCE

200 tons, making the cars the largest coal-transfer cars ever built.

The transfer-car elevator raises the pier cars about 67 ft. to the top of the pier. Heavy counterweights are used to counterbalance the weight of the platform and the car; they are so regulated that as much power is required to pull down the empty platform as is required to lift the platform and the loaded car. This arrangement permits the use of smaller motors than would otherwise be necessary.

The elevator is operated by two 450-lb. motors using a direct current at 550 volts. The gearing of the elevator is proportioned to produce a complete cycle in two minutes.

Connecting the frame of the elevator to the pier is a hinged run-off girder, introduced to insure perfect alignment of the rails on the platform and the pier. This girder is hinged to the pier in such a manner as to permit of a vertical movement of the free end amounting to about two feet. The free end of the girder rests on brackets on the elevator frame, from which it is lifted by projecting lugs on the platform as it comes to the position of its upper limit. This upper limit of travel is accurately controlled by an electric limit switch, geared to the hoisting mechanism. The power is supplied to the trolley wires in this position, and the transfer car passes out of the elevator, over the hinged run-off girder and out on the pier, where the coal is discharged to the proper pocket. The empty car then returns down the inclined track in the center of the pier structure to the loading track in front of the car dumper, taking its regular turn.

These additions to the equipment of the terminal were installed by the Wellman-Seaver-Morgan Co., Cleveland, which company furnished the original dumper. The work was carried out under direction of H. Fernstrom, chief engineer of the Virginian Railway.

Standard Boilers for Emergency Fleet

The standard water-tube boilers for the 3500-ton vessels of the United States Emergency Fleet, says the *Boiler Maker*, are of the cross-drum type, having straight tubes expanded into steel headers. Their widths are 13 ft. 4¾ in.; heights to the center of the steam drum, 11 ft. 5½ in.; depth, 8 ft. 10 in. The total heating surface is 2544 sq.ft. The grate is 6 ft. 6 in. long by 11 ft. 9 in. wide; area, 77.45 sq.ft.; the ratio of heating surface to the grate area being 33 to 1. The boilers are made for 200 lb. gage pressure, and output, under forced draft, of 15,000 lb. of water per hour, with feed water at 203 deg. F., and a combustion rate of 20 lb. of coal per square foot of grate per hour.

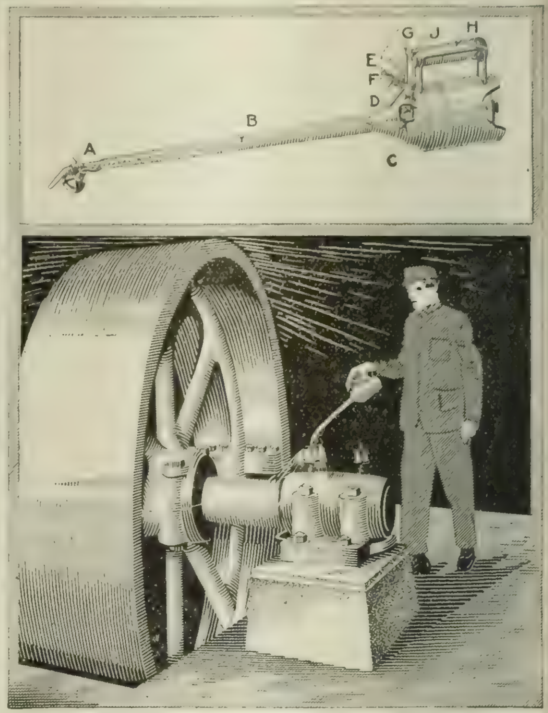
It has been proposed as a matter of great importance to the business of the country that the functions of the Bureau of Standards should be extended to permit the maker of any standard article to submit samples for examination and test, the Bureau, after such test, to certify to all the facts and findings respecting the nature and quality of the article, so that buyers, domestic or foreign, may come to a knowledge thereof and govern themselves accordingly.

Bateman Illuminating Oil Can

An illuminating oil can, intended for use by engineers where the parts to be lubricated are in dark places or for use at night, has been patented by William G. Bateman, 154 Lackawanna Ave., East Stroudsburg, Penn.

The can is of ordinary shape, but the nozzle is fitted with a valve *A* to which is attached a stem *B*, which connects with an arm *C* on a rod *D*. This rod projects to the outside of the can and has a handle *E* on its outer end. A spring *F* closes the valve when pressure on the handle is removed.

Attached to the end of the spout is a lamp socket and lamp. One terminal of the socket is connected to the spout of the can, the other terminal is wired to the hinged contact arm *G*, the wire being protected by a duct. In the handle of the can a dry battery *H* is carried, with one terminal grounded to the can. When the lever is pressed down it comes in contact with the hinged arm *G*, which closes the circuit with the contact *J*. When it is not necessary to illuminate the parts to be oiled, the hinged lever can be turned back and the valve in the spout manipulated by pressing on the lever *E* the same as when the lamp is used.



DETAILS OF CAN AND ITS APPLICATION

With firmness in the right, as God gives us to see the right, let us strive on to finish the work we are in; to bind up the nation's wounds; to care for him who shall have borne the battle, and for his widow, and his orphan—to do all which may achieve and cherish a just and lasting peace among ourselves, and with all nations.—*Abraham Lincoln.*

Combustion and Boiler Settings—I*

By A. D. WILLIAMS

The author mentions a number of interesting points concerning the location of heating surfaces, the placing of baffles and the formation of soot in relation to combustion, and indicates certain fundamentally wrong practices in the usual forms of boiler settings.

A GREAT deal of thought has been expended upon the baffling of steam boilers to obtain increased gas velocities and thereby an increased rate of heat transfer. However, there is a disadvantage in a high velocity, as the velocity head increases as the square of the velocity, and in addition there is an increase in the friction loss. The heated gases will also have less time in which to deliver their heat to the recipient surface.

With an infinite increase in velocity and a finite heating surface, the hot gases would sweep past at such a rate that the heat-transfer rate would be reduced to an infinitesimally small value and the gases would leave the recipient surface at practically their initial temperature. On the other hand, with an infinite reduction in the gas velocity the gases would lose practically their entire heat content, but the rate of heat transfer would be infinitesimally small, as before. Between these two extremes lies the desired case in which the quantity of heated gas sweeping over the recipient surface gives up the maximum amount of heat that the surface is able to absorb, between the temperature limits fixed by the heat generated by combustion and the ruling temperature of the recipient surface. In practice this problem is complicated by the surface condition of the recipient surface and the vapor tension of the hot gases.

Heat transfer is entirely a physical problem, considered by itself. Combustion is a chemical problem. In considering the industrial applications of heat, the chemical and physical exchanges and reactions must be considered together as well as separately.

CONDITIONS THAT AFFECT REACTIONS

In combustion for industrial heating the speed of the reaction depends on the intimate mixing of the reacting substances at a temperature and pressure, with a sufficient mass of the reacting substances present to permit the reaction to be self-propagating. Changes in pressure, temperature and the concentration of the reacting substances all affect the rate of the reaction and the equilibrium of the reacting system.

There are three typical combustion conditions, as follows:

1. Neutral, in which the reacting substances are present in sufficient concentration only to complete the reaction. In this case combustion will be slow, the reaction starting at a maximum rate and gradually slowing down.
2. Reducing, in which there is a deficient supply of the oxidizing or reducing element. This condition is typified by the gas producer, the blast furnace and the combustion in the fuel layer of any fire.
3. Oxidizing, in which there is an excess of the oxidizing or reducing element present.

In connection with a boiler all three of these conditions exist at different zones and each zone may occupy an appreciable space; that is, there is an appreciable time factor in the reactions. Industrial heating would not be possible without the time factor, for as the time factor becomes smaller and smaller the intensity of the reaction becomes greater and greater as its velocity increases and it finally attains explosive violence. Such combustion, while desirable in the case of a high-explosive shell, would be difficult to utilize in a furnace.

ENOUGH AIR CANNOT BE FORCED THROUGH FUEL BED

Recent experiments[1] show that the fuel bed of a furnace fired with solid fuel acts as a gas producer; that it is impossible to force through the burning bed of fuel an air supply sufficient for complete combustion; that increasing the air pressure below the grate simply results in an increase of the unit rate of combustion of the fuel and that in all cases there is a large content of combustible with no comburent (reducing element) in the gases leaving the fuel bed; and that it is absolutely necessary to introduce additional air above the fuel bed to complete combustion.

Roughly, these experiments indicate that less than 50 per cent. of the air required for a solid fuel can be forced up through the burning fuel and that the remainder of the air supply must flow into the furnace in a different way, as, for example, (a) through unignited fuel, (b) through holes in the fire or (c) by being introduced over the fire. The first two of these methods are the ones commonly—and in many cases inadvertently—in use. They are difficult to control accurately. The third method has been used for many years in metallurgical work, though even in this field there was a misconception of the reason for so doing that has resulted in misdirected effort and poor design.

With gaseous fuel the mixing of the combustible and the comburent is more readily secured and in addition it is feasible to preheat either or both of these supplies and so increase the flame temperature, making it possible to obtain high temperatures. But even in this case, where the reducing and neutral zones of combustion are at a minimum, they still exist. It is possible that these zones are even present when the gas and the air are mixed outside the burner at a low temperature, as in this case the combustible and comburent must be raised to the ignition temperature before they can combine. The same is true for liquid or powdered fuel which must be jetted into the furnace.

With any fuel it is necessary that the flaming gases remain at a temperature above their ignition point until combustion is complete. The time required to complete reduction will depend on the degree of mixing obtained, and the distance the flaming gases travel in this time will depend on their velocity, this last being a function

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*Copyright, 1919, by A. D. Williams.

[1] Bureau of Mines, Technical Paper 137

of their temperature and the temperature of the air. An illustration of the effect of mixing on the length of the flame may be had with the ordinary bunsen burner. Cover the air inlets at the bottom of the tube and the flame will be long. Open the air inlets and the length of the flame will decrease, although at the same time the velocity of flow through the burner tube will be increased, as in addition to the gas a portion of the air reaches the flame through this tube.

When the temperature of the flowing gases is known, or can be approximated, a formula can readily be derived by which the vertical velocity may be computed. Convection currents of this kind are rarely appreciated at their true velocity. A temperature difference of one degree centigrade supplies a head sufficient for a velocity of 0.88 ft. per second. As the temperature difference between the air and the gases over the fuel bed will be between 1300 and 1400 deg. C., the vertical velocity of the hot gases will be considerable. This is the reason that it has been found necessary to increase the height from the grate to the lower tubes in many water-tube boiler settings. It is the reason that boilers of the Delray, Badenhausen and Hornsby types give better results than boilers set closer to the grate. It is one of the reasons that has resulted in the adoption of oil fuel for marine boilers. At the same time the writer is convinced that from a combustion viewpoint it would be possible to improve upon the setting of boilers similar to the Delray type by a consideration of the research work of Professors Groume-Grjimailo and Yesmann, of the Polytechnic Institute of Petrograd, which has been successfully applied by them to the design of many metallurgical furnaces.

CAUSES OF FORMATION OF SOOT

In boiler practice soot is generally considered to result from the breaking up of the hydrocarbon gases distilled off below the ignition temperature of the fuel. If this is the case, it is also due to the fact that the amorphous carbon has then been chilled to a point below its ignition temperature before it has had an opportunity to combine with oxygen. There is another cause for soot formation that is not so well known; namely, the dissociation of carbon monoxide, forming amorphous carbon and carbon dioxide.

The writer has often speculated as to whether this reaction might not account for a high ratio of carbon dioxide in the off gases[2] when these gases had come at a low temperature from a boiler baffled to attain high gas velocity. This reaction is well known in metallurgical practice, for a number of years ago Sir Lowthian Bell discovered the carbon deposit caused by it in the upper and cooler portion of a blast furnace. Sainte-Claire Deville had previously discovered that carbon monoxide could be decomposed at a low red heat, giving a carbon deposit. It has been found by Boudouard and Haber that this reaction occurs between 1000 and 300 deg. C. and that water vapor contained in the off gases seems to act as a catalyzer. This reaction frequently accounts for a portion of the soot formed in the gas mains of steel plants, and the reverse reaction, the formation of carbon monoxide from carbon and carbon dioxide, occurs in the gas checkers of regenerative furnaces. This reaction may also account for a large portion of the soot formed in the rear gas passes of boilers and in economizers. It would also account for the absence of carbon monoxide from the waste gases in many cases and a resulting increase in carbon dioxide.

In boilers set in the prevailing style the off gases are generally swept over the chilling water-cooled surfaces long before combustion has been completed and every condition is favorable to the decomposition of the carbon monoxide, particularly with high-velocity baffling.

The remedy for this condition lies in designing the boiler setting so that the reactions of combustion can occur before the off gases have an opportunity to reach a water-cooled surface. This is not impossible. A partial attempt is frequently made to do this by the use of a so-called "coking arch" over the fuel bed. Henry Le Chatelier speaks of this arch as follows: "But unless this arch is designed to form a bell or inverted pocket in which the gases may remain a short time, the passage of the unburnt gases is too rapid and the effect of the combustion chamber is imaginary."

PREVENTING DECOMPOSITION OF CARBON MONOXIDE

After combustion has been completed, there will be no soot, as the hydrocarbon gases will be decomposed at such a high temperature that the resulting carbon will become ignited and there will be no carbon monoxide to decompose. A boiler furnace designed to effect this result would place the fuel bed so that no portion of the water-cooled surface was exposed to its radiant heat, and it is frequently urged that some considerable part of the heat received by boilers is due to radiation. In metallurgical furnaces fired with solid fuel it has been demonstrated that a combustion chamber and laboratory (the hearth of a reverberatory furnace) so designed that combustion was completed before the gases had any chance to become chilled gave much better results, in fuel consumption and in product heated, than one that disregarded these principles. With the elimination of soot one of the biggest obstacles to heat transfer from the gases to the metal surface disappears.

In ingot-heating furnaces it has been found that the rate of heat transfer between the hot gases and the ingots depends on the temperature difference. In this case there was no soot deposit to retard the rate of flow. In these and similar furnaces it has been found that a heat drop in the furnace of from 80 to 200 deg. C. per second between the inlet and outlet of the laboratory occurs. The quantity of material heated affects the quantity of gas required. One important feature is the location of the off-gas outlet. It is desirable to have this located so that the gases pass down to it. This location insures the keeping of the laboratory full of hot gas and the cooler gases are immediately drawn out of the heating chamber.

One of the elementary principles of furnace design and one that is frequently neglected is the fact that there is a considerable difference in the specific weight of a unit volume of gases at different temperatures. As a result of this there is what may be called chimney action. The static pressure at the top of a vertical pass may be greater than at the bottom. Where heated gases in cooling pass upward, as in a chimney, they may occupy the full area of the chimney, but the chances are very much against it. The heat of the gas may be and usually sufficient to impress a velocity upon the ascending gas ufficient to cut down its stream area, leaving the balance f the chimney area free for a downward current of cold ir and an upward one of slightly heated air. This effect ay be observed on an experimental scale by noticing he velocity of the stream of smoke ascending from he end of a cigar. This stream of smoke, it may be oticed, has an errand at the ceiling if the surrounding ir is quiet; further, it cones in just above the base and iredraws itself as it ascends. All ascending currents f heated gases act in this manner.

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[2] The term "off gases" denotes the gases resulting from either plete or incomplete combustion

The only chance for a current of hot gas to fill the full rea of the flue arises when the gases pass down the lue. A very pretty mathematical proof may be made of he theorem that when two passages are open for the scent of a current of hot gas the largest portion of the tream will pass up the passage which is the hottest, and onditions may arise resulting in reverse circulation in he cooler passage. This is one of the cases where theory nd the behavior of the hot gas agree perfectly.

Settings Usually Designed Improperly

The usual form of boiler setting is designed with an tter disregard of a principle of elementary physics; hat is, the hot gases are taken off at the top or as near he top as possible, and are introduced at the lowest point ossible. The baffling is arranged to present the largest mount of free area immediately above the grate, at a oint where the gases are hottest and have their highest ertical velocity. Then the area of the passes is de-reased, presumably because the gases get cooler. The writer will agree that the usual third pass may be small, but he cannot see any reason for a baffle separating the first and second passes. The cooler gases will fall below the hotter and lighter gases due to the difference in weight. However, it might under this ondition be desirable to extend the baffle between the former second pass and the third pass down very close o the bottom of the setting. It might seem that this would result in a short-circuit from the firebox to the hird pass. Experience with the down-draft brick kiln does not present any trouble of this character. In fact, the temperatures attained in the down-draft kiln annot be reached in the up-draft kiln.

Boilers without any baffles have been successfully sed in connection with waste-heat utilization on copper-smelting furnaces, and the same type of boiler with baffles has been used in connection with cement kilns. A better design of waste-heat boiler has been installed in connection with openhearth furnaces.

Probably the main difficulty in connection with steam generators arises from the fact that the ruling temperature is very low—so low that it would be extremely difficult or nearly impossible to design something that would not work. Many thousands of boiler installations bear witness to this. The last word in boiler designing and the arrangement of settings has not been said.

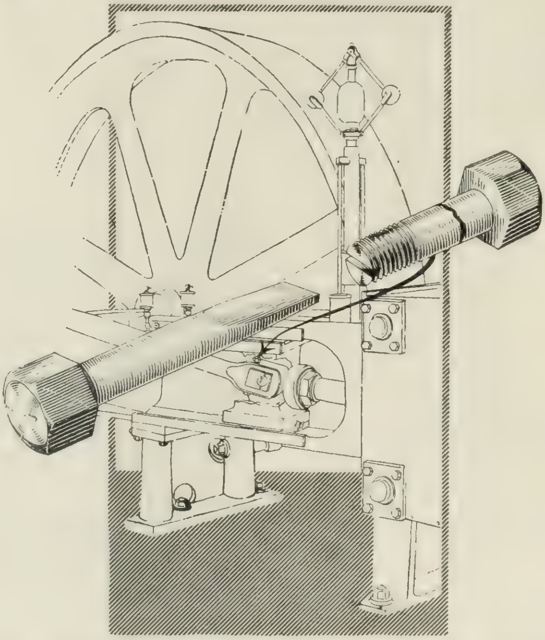
One practical feature of boiler operating that has not been touched is the dust question. The carrying power of a stream of any character varies as the sixth power of its velocity, and there are cases in which the dust evil is serious. A high velocity will tend to carry dust through the boiler, and unless the passes are properly designed, eddies will be formed which will fill up with dust in a most surprising manner. *Power* a year ago showed an interesting case of a soot deposit which settled on a horizontal baffle[3]. The cause of this was that the gases in their flow behaved as a stream, an inverted stream of water, instead of sweeping through the entire area of the pass, as the designer expected. A knowledge of the gas temperature and volume in this boiler would have enabled the designer to apply Yesmann's formula and to proportion the pass so that this eddy would not have been as large as it was.

The investigations of Mallard and Le Chatelier and of Damour enable the computing of curves from which the heat of combustion under various conditions of air supply may be very closely approximated. In these computations the assumption is made that combustion occurs in an athermal enclosure, so that the temperatures reached in actual practice are lower.

Removing Broken Adjusting Bolts

A handy tool can be made from a capscrew for the purpose of removing broken adjusting bolts from a wristpin adjusting wedge where a screwdriver cannot be used on account of the crosshead guide.

A screwdriver end is formed on one end of a capscrew and the head is left for turning with a wrench. This makes a tool just long enough so that with the engine on the quarter-stroke, there is room to insert the tool. The adjusting-wedge bolt ends are, of course, slotted with a hacksaw before being put in place.



TOOL FOR REMOVING BROKEN ADJUSTING WEDGE BOLTS

Before this tool was made it required an hour to put in a new bolt, because it was necessary to remove the wristpin from the crosshead in order to get the broken piece of bolt out of the adjusting wedge. Using this tool, it is possible for one man to do the job in from five to ten minutes.

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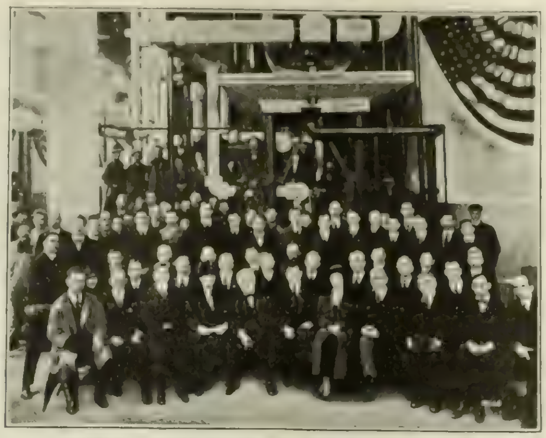
[3] Dec. 25, 1917, page 875.

Edison "Lights Up" New Boiler Plant



GROUP AT LUNCHEON IN THE BOILER HOUSE

THOMAS A. EDISON APPLIES THE TORCH

ANYONE having a mental picture of Thomas A. Edison as a laboratory dreamer, interested only in the abstruse, would revise it materially on seeing him "in action" and hearing those of his "family" at the West Orange plant tell of the intimate contact he maintains with everything doing there. It was he that started the fire under the two new 600-hp. water boilers put into service Jan. 2, 1919. This was not Mr. Edison's first introduction to the plant, for he has taken an active interest in it from first to last—no less than 14 different layouts were prepared, before his final O. K. was obtained. The boiler house, as nearly centrally located as possible in relation to the buildings served, is 90 ft. long by 60 ft. wide, with provisions for extension to a width of 100 ft. when other boiler units are installed. It was Mr. Edison's desire that reinforced concrete be used wherever possible, even to the 150-ton overhead coal bunkers and roof span of 40 ft., which proved to be difficult pieces of construction. About 11,000 bags of cement were used in the building construction. The cost of the present structure with its equipment exceeded $300,000. Considerable difficulty was encountered securing firm footing for building and stack on account of the nature of the subsoil. The stack, 10 ft. inside diameter, 202 ft. high and weighing about 1000 tons, rests on a base 30 ft. on a side, which in turn rests on about 150 wooden piles. The building basement is below the sewer grade and below the mean ground-water level, so that this floor and the lower part of the wall must not only be waterproof, but must resist a hydrostatic head of three or four feet. The two boilers just put into service constitute one-fourth of the final capacity (5000 hp.) contemplated. One of the outstanding features of the plant layout is its compactness. On the raised platform to be seen at the rear of the group in the upper picture the boiler-feed, water heater is located, giving a satisfactory head to supply the centrifugal boiler-feed pumps. The economizer is in the basement, with the scraper-operating mechanism level with the main or operating floor so that the mechanism is unusually accessible and the cleaning operation is performed in the basement, from which all the ash is removed in small cans to a skip hoist delivering to an overhead bunker. It has been the aim to design this plant to operate as economically as possible under practically constant 24-hour load. Provision has been made to return the condensate from all process apparatus through the plant to a large tank in the basement of the boiler house to be delivered to the feed-water heater and boilers. Following the lighting of the fires under the new boilers an informal luncheon was served in the boiler house in the spare space designed to receive the next two boilers, to upward of 100 guests. Charles Edison made a few informal remarks, and music was furnished by the Edison Employees' Band, led by Professor Restorfs. Mrs. Thomas Edison and Mrs. Charles Edison attended and took a lively interest in the exercises. The design and construction of the plant was in charge of John P. Constable, chief engineer; C. A. Nicolia, division manager of the construction and maintenance division; M. A. Wolf, construction engineer, and F. J. Riker, power service division manager. Among the officials of the Edison industries, in attendance in addition to the committee in charge, were: S. B. Mambert, vice-president and financial executive; C. H. Wilson, vice-president and general manager, whose retirement owing to ill health has been announced; Harry Miller, treasurer; William H. Meadowcroft, assistant to Thomas A. Edison; George E. Clark, special assistant to Charles Edison; James F. Monahan, superintendent of the Edison Storage Battery Co.; Charles W. Luhr, superintendent of the Edison Phonograph Works; William Dykeman, purchasing agent.

Reversed Heads in Pressure Vessels

BY JAMES LESLIE LANE

Notwithstanding its many advantages, from the manufacturer's point of view, many engineers believe that the reversed bumped head in receiver and pressure-tank work should be done away with. The author considers it to be one of the most abominable makeshifts allowed by the code today, and that its disadvantages so far outweigh its good points as to make its use positively bad practice.

IN THE pioneer days of the boiler industry, when but few mathematical data on such work were available and when inspection was almost unknown outside of perhaps one or two of the larger cities, it was but natural that the reversed head should have been used. Pressures were low and strength was less important than tightness. The advantage of backing a head in was obvious. It made riveting and calking much simpler, did away with a manhole that would otherwise have been necessary, and in cases where the drum was to be stood on end avoided the use of a cast-iron base or supporting framework. There was little machinery for manhole cutting or flanging, and as this had to be done entirely by hand, the cost was considerable.

Later, when pressures increased and laws were enacted covering the construction and installation of boilers, some of the objectionable features of this practice became apparent. When the tank was set vertically, it was found impossible to drain it completely; for if the outlet was placed in the center of the head there was always water remaining below that level. Locating the outlet close enough to the bottom of the shell to remedy this fault was not only difficult, but left an opening that soon became clogged. The second drawback was that this dead space served as a settling chamber and mud catcher, where oil and sediment could collect. This feature was bad as there was always a chance that the oil would eventually find its way into the boilers and cause serious trouble. This was overcome in time by demanding that tanks so constructed should be set horizontally. But there were other difficulties to contend with, especially in regard to strength.

The matter of calculating the ultimate bursting pressure of a head inserted in the regular manner, and hence its safe pressure, is not a difficult problem, although it is somewhat complicated by the fact that a bending moment is introduced at the point where the flange and the head proper join. This causes the head to breathe slightly under excessive pressure, but the error it introduces into such calculations is not serious. The case of a bumped head resisting collapsing pressure is far more difficult, however, as it is somewhat analogous to buckling in bars. If the cross-sectional area of a bar is known, as well as the tensile strength, its ultimate rupturing strength can be accurately determined. What the same bar will do under a compressive stress depends on its shape, length, manner of applying the stress, etc. The formulas for determining its resistance to buckling are mostly empirical; that is, deduced from actual experience and tests. The same is true of bumped heads, the number of factors introduced and the uncertainty of their action making a clear-cut and exact mathematical formula out of the question.

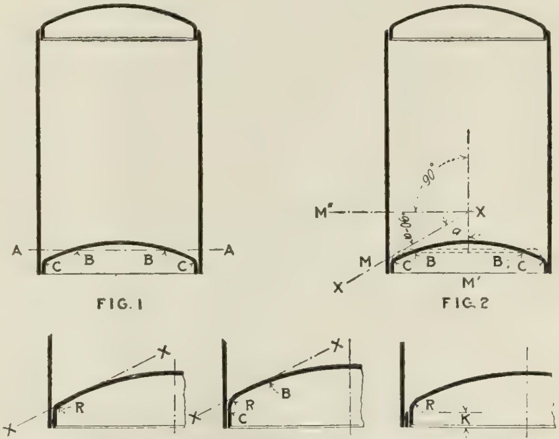


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5

FIGS. 1 TO 5. DIAGRAMS SHOWING ACTION OF FORCES IN DISHED HEADS

Not a little hinges also on the individual workmanship and the accuracy with which the head is shaped to a given radius. Before collapse can begin, some small part of the head must be flattened by the pressure. This is difficult if the curvature is exactly the same at all points on the sphere and the stresses set up in it are balanced; but if in the beginning some small portion is left flat and a leverage afforded the tendency to collapse is cumulative. In fact, it might be said with fair accuracy that in every case where such failure occurs under pressure the beginning was made at a flat spot.

Where the pressure is on the concave side, such a fault tends to correct itself by forming the head to a circle; in a reversed head it tends to accentuate itself and lead to a failure of the whole. Accurate workmanship cannot, therefore, be too strongly insisted upon.

Installing a badly shaped head is analogous to putting into a building columns that are already buckled and out of true. Both invite failure and should not be tolerated.

These faults, the impossibility of deducing an accurate formula for collapsing pressure and the practical certainty of imperfect curvature, have been allowed for by stipulating that such heads shall have a minimum thickness considerably greater than would be the case if they were put in in the regular manner and the pressure applied on the concave side. These restrictions take care of the stresses set up in the head itself, but do not allow for the effect of breathing or swaying on the shell.

Turning to Fig. 1, observe what form the bumped head will first assume when a distorting pressure is applied and what stresses it will develop in the shell. The problem is similar to buckling in a beam, and whatever distortion appears will be about the neutral axis AA, no effect being noticeable at the points B where the axis cuts the head.

If the part BB is to bulge outward finally, it must first be flattened, the part BC of the head being distorted and assuming the shape shown in Fig. 2. This places the part BC in compression and the stress will be exerted along the tangential line XX. Without attempting to determine the exact intensity of this stress, assume it to be M pounds and resolve it into its two components, one parallel to the axis of the shell, the other at right angles to it.

Supposing that the line XX makes an angle a with the axis of the shell, then the force M' acting parallel to the axis of the drum will be $M \cos a$ and its effect will be wholly exerted on the rivets holding the head in position. The force M'' acting at right angles to the axis of the drum will be $M \cos (90 \text{ deg. } a)$ and its effect will be partly exerted on stretching the metal in the part BC of the head, and in expanding the shell of the drum itself. To put the problem in a simpler way, the action is a toggle effect, the outer rim of the head being stretched and forced out against the shell, tending to rupture it.

Just how much of this toggle effect is brought to bear on the shell of the drum depends on the radius R, where the head meets the flange. If the radius is small, as in Fig. 3, then any expansion of the head must affect the shell, for the thrust comes directly against it. On the other hand, if this radius is large, as in Fig. 4, the part BC of the head is free to spring and the stretching of the shell is minimized. This would lead to the conclusion that in reversed heads the radius at the knuckle of the flange should be considerably larger than in the case of straight dished heads of the customary type. In order to reduce still further this toggle effect, the writer believes it would be advisable to insert a filler piece between the flange of the head and the drum, as shown in Fig. 5. It need not be thick—probably one-eighth inch would be sufficient—and where possible it should be of copper. Its width K should not exceed 2½ in., in order that a clear space be left above to take care of any expansion of the head.

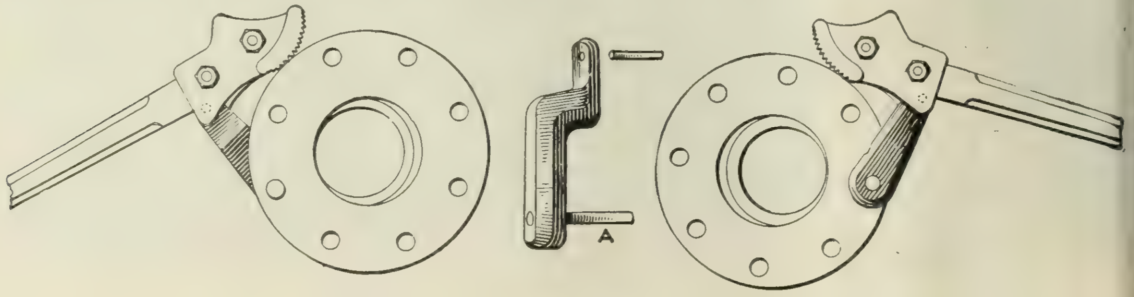
Summing up, then, the advantages of a reversed head are: (1) The possible elimination of a manhole where the drums are small; (2) the elimination of a cast-iron base or supporting lugs where the drum is to be set in a vertical position; (3) the possibility of doing the riveting on a bull.

Opposed to these are the following disadvantages: (1) The impossibility of proper draining, with the attendant danger that oil may find its way into the boilers; (2) the settling chamber formed, and the danger of clogging the outlet pipes; (3) the additional thickness of plate required; (4) the wholly empirical formulas on which such plate thickness must be based; (5) the ever-present element of danger due to faulty curvature; (6) the additional load that such construction puts on the shell joints.

This latter list is a formidable one, and where safety is a necessary factor to be reckoned with it far outweighs any initial saving in construction. The defects are too glaring, and in offering the foregoing suggestions the writer does not mean that such changes would entirely eliminate them, but would rather minimize their effect in cases where such doubtful practice is adopted.

Ideal Flange Attachment

Engineers are familiar with the chain type of wrench, in which the gripping jaws are toothed to prevent slipping on the pipe, and a chain causes the gripping head to grip the pipe as pressure is applied to the handle. An attachment has been made to be used in connection with the chain wrench, shown herewith, known as the Ideal flange attachment and made by Kroeschell Bros. Co., 440 West Erie St., Chicago, Ill. As shown in the illustration below, the attachment consists of but one member, a steel link A. One end swings on a pin held between the jaws of the wrench members, and the other end carries a pin that engages in the bolt holes of the flange. When used, a grip is obtained on the rim of the flange. This wrench with flange attachment is made in six sizes with a total range of from ½ in. to 20 in. in pipe sizes.



EDITORIALS

Wages and the Engineer

IN THE reconstruction problems now confronting the industrial world, the question of wages and wage-cale adjustment takes a prominent and highly important part. Reconstruction in its broadest sense brings added responsibilities, creates greater need for onscientious and rightly directed thought, and demands a careful exercise of judgment for resultant action. And so, indeed, with the wage question, for probably no other phase of industrial operation is of such primary onsequence from the viewpoint of both employer and mployee.

Of the former there are two general classes. On the ne hand is the man or concern that seeks to "cut" ight and left to save so-called overhead, regardless of onditions or circumstances, and with equal disregard or ultimate consequences. But little thought, frequently, is given before acting, the one and sole aim being to "save the dollar"—and the dollar is held so lose to the eye there is no seeing beyond. On the ther hand stands the right-calibered executive, the man who thinks before he acts, and in that thinking arefully takes into consideration all factors that go o make up the full situation, such as plant atmosphere, mployees' welfare and living, as well as general betterment, and the big values to be derived for the business by helping his men to maintain a present or right status f home and existence.

Among the wage earners, and primary wage earners, re the stationary engineer and fireman. The results f their efforts are of vital importance—they start the wheels of the plant or factory moving, for without team or electric power for operation there can be either industrial activity nor works production. To a ar less degree than skilled workers in other lines of ndeavor have these mainstays of factory operation been benefited by advancing wages. There have been general increases in wage rates here and there, for such ad to be with the advancing costs of living, but the ncrease has been small compared with the added compensation in other lines. Shall this advance, such as it as been, now be taken away and former schedules esumed? It would seem not only unfair to the men irectly concerned, but decidedly wrong and injurious, nd in more ways than one.

Thus when we find a body of employers getting together in common council and urging a maintenance of wages for the engineer and the fireman, as well as or skilled workers and even common labor in other ranches of industry, we are impressed with the fact hat a sort of new spirit is alive, that the day of real coöperation is here. Unquestionably, it is a big move n the right direction; it is the impelling force of right coördination, which cannot help but be substantially beneficial.

At a recent meeting of the Manufacturers' Council f the State of New Jersey, held at Newark, the wage question occupied a first place in the discussions of the day. This gathering, known as a readjustment convention, was the first of its kind in any state of the Union. Here it was pointed out that the desire on the part of all, both employers and employees, was for a return to the normal working day, with elimination of overtime, and further, that employees in the average run sought only a right wage schedule commensurate with the present cost of living. In line with these views a resolution was adopted unanimously, reading:

> It is the sense of this convention that wages should be the last thing to be reduced, and that, in justice to the worker, in so far as possible, present wage schedules be maintained until the purchasing power of the dollar increases.

Another interesting result of the meeting was the formation of an Industrial Commission for the Council, to bring about friendly coöperation on the part of manufacturers in different lines, formulate definite plans for matters of immediate readjustment, and effect a better understanding, where needed, between employee and employer. This commission will be composed of five members each from four primary branches of industry—manufacturing, public utilities, agriculture and banking—and a total of ten members to represent labor. Five of these latter will represent the power end of business, termed public utilities in the broad phase, giving a hearing to the engineer, firemen and other power-station employees, as might be desired.

The plan as arranged carries every earmark of successful attainment. There is no better way to iron out difficulties, regardless of their nature, than to get together in common council on equal ground and "talk it over." Fully one-half, if not more, of the trouble disappears when the two sides meet, and the rest can be taken care of readily and in the right manner by a fair and impartial discussion and an equitable adjustment satisfactory to both parties.

Employers in other states might well watch the results of the New Jersey Industrial Commission. That they will be followed with interest there can be no question, and every indication goes to show that the engineer and power station employees, as well as general industrial workers, will be given not only a "square deal," but in the spirit of reciprocity, considerate and fair-minded treatment; and in the initial as well as final reckoning, they themselves will have an important voice.

Cost of Banking Fires

ONE of the items that enters into power-plant costs, and that cannot be directly figured in the production of power, is the coal used in banking fires, during the night in some instances and during the day in others, where some of the boilers are used to carry the morning and evening peak loads.

Naturally, the attendant will burn his fires down before the banking period. With hand firing the live coals are pushed back against the bridge-wall and covered with sufficient green coal to carry the fire over the banking period. With stokers various methods of banking are employed, depending on the type of stoker. Regardless of the type of furnace, the coal used for banking fires cannot be figured in with that burned to evaporate water. As a matter of fact, very few boiler plants keep a record of the amount of coal used for banking and still less is known as to how much of the banking coal is consumed during the banking period.

Naturally, the size of the boiler and the period of banking will determine largely the amount of coal used in banking fires, but other factors also enter, such as the condition of the damper and kind of coal used.

It has been estimated by some that the coal required for banking is about one-third of that required for the day's run. This seems somewhat high, but in the absence of published data covering the subject, there are but few figures to confirm or disprove this estimate.

It would be interesting to know what engineers in various types of plants have found regarding the amount of coal used in banking fires; also, the amount that is consumed during the banking period. It is probable that many engineers have these data, but have not deemed them of sufficient importance to give to the technical press for publication. The fuel situation at the present time makes it imperative that every engineer shall know just what amount of coal is consumed for the various operations in his plant, and that of banking is no exception. If there are engineers who have kept a record of the coal used in banking fires, others who are interested in this subject would welcome these data, and we shall be glad to publish them.

The Engineer and Conservation

FOR the operating engineer and all power-plant operatives, the events of the last four years brought forward only a few new problems, the chief one being that of obtaining supplies, particularly an adequate supply of fuel. Economy in the operation of the plant in every particular is not a new problem or a new practice to the first-class man in any plant, large or small, in which he may be found.

It would seem from the popular press that a study of economy was something new and entirely foreign to the power plant and the engineer. The fact of the matter is that there are few if any trades or professions in which men continually devote more time and money to maintain organizations for the study of their work, for the benefit of their employers and in the hope of advancing themselves thereby, than that of the stationary engineer. In many places the men meet and devote an entire evening a week to educational work, paying their dues cheerfully to defray the expenses for hall rent, heat, light, etc., without a "come back" from anywhere. It is a safe challenge to those in any other line to show a greater effort toward personal proficiency than has been the practice of the stationary engineers for the last twenty-five or thirty years.

The struggle for economy and efficiency in the power plant is new to the general public and in many cases to the management, which is now coöperating to some extent, but it is by no means a new thing to the engineer. Now is the time for the engineer to show what he can do when given the proper support.

No Government Bargains in Power Plant Apparatus and Supplies

THE sudden close of the war has found the Government with a large amount of machinery and supplies upon its hands for which it has no further use. Opportunities for bargains are being sought, both by those who have legitimate use for such machinery and supplies and by those who would like to purchase them at a sacrifice price and resell them at the market value.

L. H. Hartman, Chief of the Surplus Property Division, in a recent address to the Chicago Association of Commerce, explained that as many of these goods as possible would be disposed of to foreign countries and to different departments of the Government. Contractors and purveyors of supplies will be given every opportunity to repurchase, so that the unloading of these goods upon the market may not interfere with their regular trade. Only after such sources of distribution have been exhausted will individual purchasers be considered.

By a study of the load curves, desirable results have been accomplished in Massachusetts. It has been found possible to shut down generating units hitherto in continuous operation to take care of peaks. Now that the war is over there should be no let-up in studying peak loads and other power-plant conditions. Conservation of fuel is still the order of the day, not particularly because of a coal shortage, but because wasting coal is wasting money.

Caring for hot-water heating systems is viewed from different standpoints. Opinions are divided as to the advisability of emptying the system of water at least once a year. Some are in favor of so doing, others are opposed. What is the opinion of users of hot-water heating systems?

The model soldier does what he is told to do, in the way he is expected to do it. If there were more of that spirit in industrial life we should not hear so often the familiar complaint, "If you want a thing done the way you want it done, do it yourself!"

Until quite recently the only standard that the United States Army had for buying coal was that it should be equal to a ton of good hard wood. Some of the alleged coal that was sold last winter would make a pretty big dent in even that standard.

How things change! It was only a few years ago that an editorial in a then well-known technical journal discussed the question as to whether the steam turbine was suitable for driving dynamos. Wonder what the author thinks today?

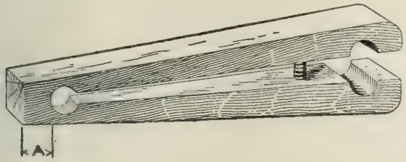
By what principle of economics is it figured out that the best way to keep a people from suffering for the necessities of life is to keep them at work making something for which they will have no need?

As a general proposition, the higher the furnace temperature the greater the efficiency. If you believe this to be so, stop up those cracks in the boiler setting.

CORRESPONDENCE

Tool for Removing Fuses

It is sometimes difficult to remove small inclosed fuses from their clips, especially if they happen to be in an inconvenient place. The illustration shows a very serviceable pair of fuse pliers I made of a piece of fiber. Two holes about ¼ in. in diameter are drilled in a solid piece of fiber, and then the block is sawed open as in the sketch herewith, thus opening the pliers. Inserting a small steel spring as shown will keep them open normally and make them convenient to use with one hand. The distance *A* can be made suitable to the user's fancy; in mine it is about $\frac{3}{16}$ in.



HOME-MADE FUSE PLIERS

Norristown, Penn. **William H. Watson.**

Practical Coal-Saving "Stunt"

Since we have been told that engineers must save at least 35,000,000 tons of coal this winter, the following true story of how one superintendent cut down the consumption of fuel at a small power plant is of interest: After he had heard the cry, "Save coal and more coal," he thought he would try and see if he could do anything that might cut down the fuel consumption. Being an old hand at firing, he stayed around the fireroom to see if the boys understood their business well. He discovered that they were pulling the fires before they had gotten the full value of the fuel and that they were not firing in a proper way, heaping the coal right in the center of the fires. He showed them that it would be easy work for them to keep up the steam and save coal if they would keep their fires level and not be continually damping them by putting fresh coal on. To their surprise the superintendent reported at the end of a week that they had saved 4½ tons of coal. In one year that would amount to 225 tons saved on four fires.

These facts prove the truth of the saying that it is the man with the shovel who controls the use of coal.

Plymouth, Penn. **Joseph R. Thomas.**

What Is an Engineer?

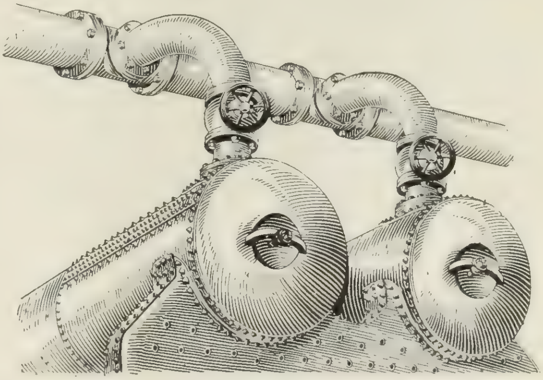
A. H. Krom, Director of Engineering, United States Employment Service, has proposed the following definition of an engineer: "An engineer is one who economically directs man power and by scientific design utilizes the forces and materials of nature for the benefit of mankind." This definition it would seem admits many men to the engineering profession who are not engineers. There are many men economically directing man power who have nothing to do with engineering. It seems to me that the definition should be changed, and the following is suggested: "An engineer is one who economically directs man power in the utilization of the forces of nature and the use of the materials of nature for the benefit of mankind."

In regard to the definition for a mechanical engineer, the following has been suggested by Prof. J. J. Flather, of this University: "A mechanical engineer is one who scientifically designs, or economically directs the construction and operation of, machinery and mechanical apparatus for the benefit of mankind."

John R. Allen,
Dean, College of Engineering and Architecture,
The University of Minnesota.
Minneapolis, Minn.

Difference in Water Level

The letter by C. S. Regan in the issue of Nov. 26, 1918, page 786, calls to mind an experience I once had with a battery of two-drum horizontal water-tube boilers. As shown by the illustration, each drum was connected to the header by an independent steam line. When cutting one of these boilers into service, if the stop valve on the drum to which the water column was connected was opened first, the water would rise to the top of the column and the header would be flooded, while if the valve on the other drum was opened first, that header would be flooded, but the water would disappear from the column. This, of course, was the result of the unbalanced pressure in the drums, due to opening the valves one at a time.



TWO-DRUM BOILER WITH TWO STEAM CONNECTIONS

To avoid the trouble, it was only necessary to open both valves simultaneously, thereby maintaining a practically balanced pressure in the drums. If Mr. Regan's boilers were connected up in the same manner, it is possible that the flow of steam from one drum is more restricted than from the other, owing to friction in the steam lines which results in an unbalanced pressure of perhaps only a fraction of a pound. A column of water one inch high exerts a pressure of less than six-tenths of an ounce per square inch, so it can readily be seen that a difference in pressure of a very few ounces could easily account for a difference of two or three inches in the height of the water. If the drums were connected by a cross steam drum with a single outlet, my theory (if such it may be called) would hardly apply, unless the steam legs of the cross-drum were served by dry pipes having unequal area or the flow of the steam through one of the legs was otherwise restricted. As no difference in water level developed until the boilers were cut in on the header, this would further support my claim that an unbalanced pressure existed in the drums, due to an unequal flow of steam therefrom. T. D. BROWN.

Akron, Ohio.

If the water level is the same in both columns when the boilers are not working, the trouble must be in the steam outlets to the main. The one in the drum that the water rises higher in must be the larger. Uneven heat and uneven draft or fire under one drum would cause the water to circulate more rapidly, and the water would rise higher in that drum. If both steam and water connections of the columns are direct from the drum and are the same size and are clear of scale or have the same number of elbows and tees up to the column, then the trouble may be in the gage-glass valves.

I once had such an experience and found my trouble in the gage-glass steam connection. The steam valve had become almost closed up by scale and pieces of packing. Some water glasses have small needle valves and the steam end may be almost closed off and the water end wide open, and with the boiler working, the water will rise two to four inches higher in the glass than the true water level in the boiler. A good way to test two columns would be to connect both to the same drum on the same pipe; then if they show the same water level, it must be overheat or overcirculation in the drum that influences the water level. I have never seen two boilers that worked just alike or any two-drum water-tube boiler that had an even circulation in both drums. P. B. WILLIAMSON.

North Kansas City, Mo.

I have had considerable experience in the operation of large cross-drum boilers, and a similar problem was once encountered. The boilers in question were 44 tubes wide and were equipped with a double-loop superheater. The steam outlets were at either end of the superheater header, which ran the full width of the setting. The boiler was fired with two underfeed stokers, one being located at the front and the other at the back. The boiler was fitted with two water columns, one at either end of the drum, and indicating thermometers were supplied on each steam outlet. For some time it was noticed that a considerable difference, fully three or four inches, existed in the level of the water in the two columns. This difference was especially marked when the boilers were being forced. It was finally discovered that the temperature of the steam leaving one side of the boiler was considerably higher than that leaving the other side and that the hottest steam was indicated on the side of the boiler showing the highest water.

To account for this a thorough study of the conditions in the boiler was made. It was found that one side of the fire in the furnace was in considerably hotter condition because the coal was fed to the stokers by a coal chute that was placed at such an angle that the coarse coal all went to one side and the fine went to the other. This, of course, caused very uneven fires with the result that one side of the boiler was evaporating more water per square foot of surface than the other. The gases were so much hotter on that side that the steam in the superheater was much higher in temperature. This condition existed until the coal chutes were replaced by traveling weighing lorries which gave an even distribution of coal over the entire stoker. After this it was, of course, possible to carry fires that were more nearly the same all the way across the furnace. From that time on the discrepancy was less apparent and it was possible, at times, to have the steam temperatures read within a few degrees of each other. The water levels also were more nearly the same.

While it would be necessary to know more of the conditions that existed at the time the trouble occurred as described in the article of Nov. 26, it would seem that part of the trouble, at least, may have been due to uneven fires. This would cause the water to boil much more violently on one side of the boiler than on the other and cause a higher water level in that drum.

Hazleton, Penn. F. C. TORRANCE.

Trouble with Belt Tighteners

The illustration submitted by Mr. Eckert (Dec. 10, page 856) shows a tightener that is moved into and out of contact with the belt by means of a handwheel, screw and gears and that the tightener is nearer the driven pulley, which in this case is the smaller of the two. A so-called "tightener" in addition to increasing the tension should increase the arc of contact of the belt on the smaller pulley and should therefore be placed near the smaller pulley. In the installation described, however, the idler should be placed near the driving pulley for the reason that this is where it will best take care of the stretch in the belt that occurs with a sudden increase of the load. The tightener should be of the swinging or of the weighted type because the hand-operated kind will not adjust itself to the stretch of the belt. Whether the idler pulley is straight or crown-faced does not matter so much provided it is square with the belt. Mr. Eckert's difficulty is no doubt due to the use of the fixed type of tightener, wrongly placed and probably a little out of line, any one of which elements will cause trouble.

There seems to be some prejudice against the use of idlers on belt drives. This is pretty much due to the erroneous impression that they absorb a lot of power. The writer in discussing a certain belt drive with an engineer, suggested the use of an idler. The engineer said he was opposed to the use of idlers on account of the large amount of power consumed by them and that the idler suggested would require at least five horsepower. He was surprised when a calculation involving the heat equivalent of five horsepower and the probable heat radiation disclosed that any such absorption of power would soon melt the bearing liners. As a matter of fact the power consumed by this idler was but a fraction of a horsepower. C. O. SANDSTROM.

Kansas City, Mo.

Such problems in belt transmission are not unusual. It is probably the result of installing a belt that is too small to carry the load with ease. If the belt and pulleys have been kept clean and the belt pliable, the need of a mechanical tightener would indicate that the belt was too light.

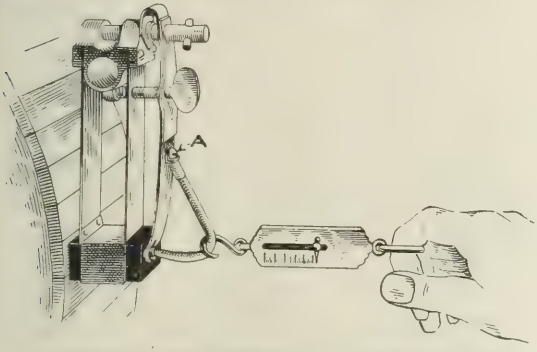
Since tighteners are always a source of danger and annoyance, I would suggest the installation of a "rider belt" of two-thirds to three-quarters the width of the main belt. This rider should always fit snugly with little sag on the negative side. It is in a measure a remedy for the trouble; for by its action it holds the main belt more firmly against the pulleys, reducing the tendency to slip, and greatly reduces the "jump" in the main belt when it does slip to relieve the sudden excess load, and very materially increases the efficiency of the drive.

It is well to remember constant care is the price that must be paid for good results in belt transmission and that neglect and abuse result in loss. J. F. ENGLER.

Tyrone, Penn.

Testing Brush-Holder Spring Tension

When testing the spring tension on motor and generator brushes by means of a spring balance, it is a common fault to hook the balance to the pigtail of the brush as in the sketch. This is incorrect since there will also be a pull at *A*. The proper method is to disconnect it from the clamp holding the pigtail and then pull on it radially. WILLIAM H. WATSON.



TESTING SPRING TENSION OF BRUSH-HOLDER

Norristown, Penn.

Repairing a Cracked Water Jacket

The water jacket of a gasoline engine was cracked in two places. One of the cracks was a very fine one, while the other one was more open. The larger crack was brazed in the following manner: First, to prevent the cracks from lengthening, holes about $\frac{1}{8}$ in. in diameter were drilled and tapped at each end of the cracks and fitted with iron machine screws coated with shellac to make a tight fit. The wide crack was then prepared for brazing. With a sharp-pointed file the sides of the crack were carefully cut away to form a V-shaped groove, as shown in Fig. 2. Along the bottom of the V, or crack, a very soft brass wire was placed and powdered borax sprinkled over it. The surface around the crack was first heated carefully with a blowtorch and the torch finally brought to bear upon the brass wire over the crack. With sufficient heat the wire was melted and fused into the crack.

The fine crack was not brazed but copper-plated. The water jacket was filled with a saturated solution of copper sulphate (blue vitriol) made by dissolving the crystals in warm water. At first the liquid leaked through the fine crack quite freely, but it was collected in a pan and poured back into the jacket again. After a time a coating of pure copper was formed in the crack, filling it up and making it tight. The job was considered done, but after the engine had been given a short run, a little leakage was still noticeable. To eliminate this fault, the copper-plating process was applied again by holding the copper-sulphate solution under air pressure by the use of a tire-inflating pump, as shown in Fig. 1. A few strokes with a tire pump was sufficient to create a pressure in the jacket, and when the copper plating was finished there was no leak even under pressure nor was there any leak when the engine was put into service. B. Z. REITER.

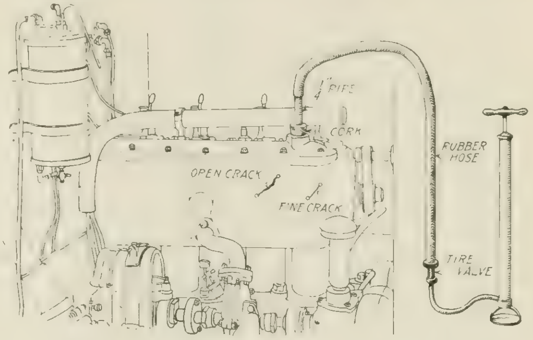


FIG I

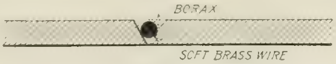


FIG 2

METHOD OF APPLYING THE COPPER SULPHATE

Hoboken, N. J.

A Couple of Drinks

There is no excuse for the man who comes on watch with a "couple of drinks under his belt." He is a dangerous proposition and a useless drag on the morale of the rest of the crew. His efficiency is negative as compared with the man who does not require the proverbial "morning eye-opener." His mental faculties are used mostly in marking time, counting the minutes until he can get an opportunity to replenish his false stimulation. And the average drinking man is very much conceited about his so-called self-control. He says he can "take it or leave it," but he never feels inclined to leave a glass just to illustrate his will power.

In one plant there were two Corliss engines driving generators. One night, with the smaller unit on the line, the night engineer and his oiler took charge as usual. About 6:30 the crank-end dashpot refused to operate. Instead of starting the other engine or trying to ascertain the cause of the trouble, the engineer took a crowbar about five feet long and attempted to pry upen the dashpot. It came up all right, but when the travel of the valve gear reversed, the pick-up hook pushed the block down again with the result that the bar struck the man, breaking his jawbone, and in some unknown manner, when he fell to the floor, his ankle was broken.

All that was wrong with the engine was that the locknut had jarred loose on the dashpot rod and the rod had shortened until the hook could not engage the block in its limited travel. The rod could have been easily adjusted temporarily by hand and the top locknut tightened with an open-end wrench—which, by the way, hung on a tool board about ten feet from the engine.

The man's case was taken into court and on the witness stand he admitted that "he might have had a 'couple of drinks' before he went on watch," but it was proved that he was in four different saloons on his way to work that night. His partner, who he relieved, on being questioned, said that he had not noticed anything wrong with the night man. Maybe not, but he was partly to blame, inasmuch as he left the plant without knowing that everything was right. Fortunately, such incidents are rare, but it seems that a man should have enough sense of honor, if he has to drink, to stay away from the plant while he celebrates. His conduct reflects on all his associates, indirectly.

The gradually increasing load of responsibility resting on the man who operates power-plant equipment is of such a nature that it surely does not permit the couple of drinks. In the case mentioned, a "couple of drinks" cost a certain company approximately a thousand dollars a drink. The lesson is evident.

Chicago, Ill. JAMES J. JAHOBART.

Firing Low-Pressure Boilers

In regard to the cause of the water returning when the steam pressure was lowered in the boilers, as described by J. M. Coleman in the issue of Dec. 10, 1918, page 837, I would refer him to my letter on page 855 in the same issue.

When a lower pressure was carried in the boilers, a lower column of water would be supported and less water would be stored in the system. To my mind this is the cause of what took place and not the more or less rapid circulation of the water in the boilers.

Buffalo, N. Y. THOMAS SUTCLIFFE.

Overcoming Flash-Over Troubles on Direct-Current Generator

In the plant where I am in charge there are two motor-generator sets for electric-railway service. Each set consists of an 11,000-volt synchronous motor, driving a 600-volt 481-amp. direct-current generator, and has been in use for about nine years.

For a long time after these machines were installed, they gave considerable trouble by flashing across from the commutator to the brush-holder yokes and frame about every time a heavy short-circuit occurred on the system. Since this trouble occurred on the generators, the circuit-breaker could not protect the machines, consequently the overload always stalled the motor and often roughed the commutator of the generator, causing considerable interruption in the service.

The trouble was overcome about two years ago by raising the brush-holders about ⅜ in. from the commutator. We also painted the brush-holders with an insulating paint and wrapped the yoke with linen tape. But I think raising the brush-holders was what overcame the trouble. At any rate, no flash-overs have occured on the machines during the last two years.

Deadwood, S. D. W. W. CASSIDY.

Unusual Cause for Circuit-Breaker Heating

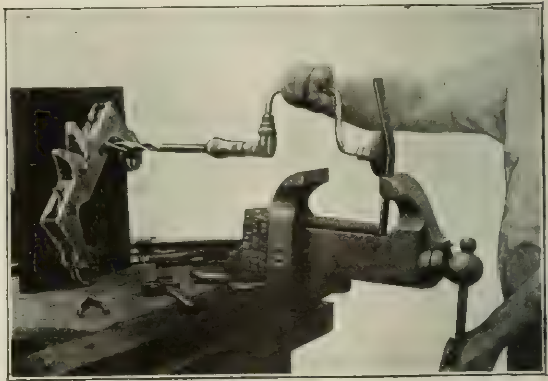
We had trouble some time ago with a circuit-breaker heating. The contact surfaces were thoroughly cleaned without avail, and the breaker was taken down and given a further careful cleaning, but still it heated up.

The rear connections were then looked over, and in taking off the nuts that held the top contact it was found that the thread of the stud had been crossed when screwing it in and the poor contact had caused heating, which had resulted in oxidation and arcing, the stud being half eaten through by it. A new stud was put in, after which no further trouble was found.

Norristown, Penn. WILLIAM H. WATSON.

Drilling with the Vise

The rig shown in the illustration will often solve drilling problems when a drilling machine is not available. A ratchet brace is used for the movement of the drill and the feed is obtained by means of the vise, which is equipped in the manner shown. An angle-plate or any suitable object can be employed for the proper location and backing for the piece to be drilled.



METHOD OF DRILLING WITH THE VISE

Samuel Gompers, speaking at a dinner recently, said: "The American labor movement, as represented by the American Federation of Labor, is simply this: We believe in progress. We believe that all the fruits of the genius of the past ages and of today do not belong to any particular class—that they belong to every man who gives service to society and aids civilization."

INQUIRIES OF GENERAL INTEREST

Irregular Water Level in Glass Gage—What causes the water in a gage-glass to continually rise and fall? E. E. R.

Fluctuations of the gage-glass water-level may be caused by a surge or wave of the water in the boiler, due to circulation, or it may result from irregular formation or release of steam in the parts of the boiler to which the water column is connected.

Use of Bent Rocker on Valve Motion—Why is a bent rocker used on many high-speed engines for operating the valve rod? J. E. S.

With a symmetrical rocker and a valve with equal laps, the port openings will be equal but the piston positions at cutoff will be very unequal and equalization of the cutoff must be at the expense of the lead. By the use of a bent rocker an irregularity may be purposely introduced into the valve motion that may be made to equalize the cutoff without interfering with the equality of the lead, which is of greater importance than equality of port opening.

Slippage of Riveted Joint—In a riveted boiler joint is movement of one plate over another a sign of poor construction or weakness of joint? F. M.

Samples of carefully constructed riveted joints, when placed in a testing machine, reveal considerable slip long before the working load of the joint is reached. Some slip is unavoidable, for although the rivets when hot may be set with great pressure to completely fill the rivet holes, there is shrinkage upon cooling, and when the friction between the plates is overcome, some slip or "take up" is necessary for the rivets to come to a bearing for resistance against shearing.

Removing Soot from Water-Tube Boiler—Is it a good idea to clean soot from the tubes and baffles of a water-tube boiler by washing down with water from a hose? R. P.

Washing with water should be done only when the boiler is cold and will be injurious to the brickwork of the setting and cause firebrick baffles to crumble if the boiler is used before the setting has been slowly dried out. It is better and also more convenient to remove soot by blowing it off with dry steam, which can be done while the boiler is in use and when there is good draft for carrying off the lightest particles of soot.

Point of Suspension of Stephenson Link—What determines the location of the point of suspension for a link of a Stephenson link-motion valve gear? S. D.

The complex motion of the link and constrained motion of the block give rise to a slippage or rubbing of the link upon the block. The nearer the block is to the point of suspension the less there is of this slippage, and the link usually is suspended nearer the end connected with the forward eccentric rod to reduce the wear for the more common working position. The slippage in backward gear is thereby increased; but when equal efficiency is required in both forward and backward gears, the link is suspended from the center.

Connecting Live-Steam Heating to a Condenser—Is there any benefit in connecting a condenser on heating coils supplied by high-pressure steam direct from the boiler except for the purpose of collecting the condensation for return to the boiler? S. C.

Any form of condenser for continuous operation would be provided with means for discharge of air, and that feature of operation would be beneficial to any system of steam heating to prevent formation of air pockets and thereby increase activity of the circulation of the steam. The heat that is imparted to the condenser is lost if the condensing water is discharged as waste or is of no benefit in increasing the temperature of the boiler-feed water. But for most purposes of live-steam heating, and especially where the steam is used at reduced pressure, a condenser and air-pump connection is of benefit for at least occasional removal of air without extravagant waste of steam, as by blowing out returns and leaving air vents open to the atmosphere. It should be borne in mind, however, that condensation is necessarily accompanied by a drop in pressure and temperature in the heating system, and during operation of the condenser it deprives the heating system of steam that must be made up in the supply, and the heat thus absorbed by the condenser is lost unless utilized.

Negative Part of Indicator Diagram—What is meant by the negative part of an indicator diagram? W. R.

A negative portion of a diagram is any part in which the pressure during the forward stroke of the piston is less than the counterpressure indicated for the same part of the diagram during the return stroke of the piston.

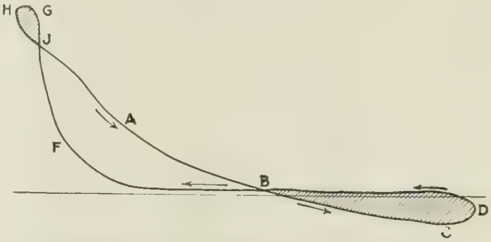


DIAGRAM WITH NEGATIVE AREAS SHADED

When an engine is underloaded, the fraction of stroke at cutoff may be so small that expansion during part of the forward stroke goes below the back pressure during the return of the piston over the same part of the stroke, forming a loop like *BCDEB* shown in the sketch; or the compression line *FG* may rise above the admission line, forming a loop like *GHJ*. The areas contained within such loops are said to be negative because they represent work opposed to the useful work, and in determining the m.e.p., the whole length of the diagram is taken and the negative areas are to be deducted from the area of the rest of the diagram.

Pressure of Compressed Air for Air-Lift Pump—What pressure of compressed air will be necessary for raising water by an air lift from a well 140 ft. deep where the air pipe is submerged to a depth of 60 ft.? T. S.

For operation of an air lift it is best to supply the compressed air at no higher pressure than necessary to inject the air through the footpiece or air nozzle of the lift, for which purpose the receiver air pressure needs to be only great enough for overcoming pipe friction of the air and the pressure of water due to the depth of submergence. A submergence of 60 ft. would require an injection air pressure of $60 \times 0.433 = 25.98$, or practically 26 lb. per sq.in. The loss of air pressure from pipe friction would depend on the size and length of pipe and quantity of air to be delivered. Allowing this loss to be 5 lb. per sq.in., the receiver pressure would need to be $26 + 5 = 31$ lb. per sq.in. If the submergence of 60 ft. becomes less from a drop of the level of water in the well, then the air pressure should be reduced to the pressure for which the greatest discharge is obtained.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Annual Report of the Secretary of the Interior

The annual report of Secretary Franklin K. Lane for the fiscal year ended June 30, 1918, is an exceedingly interesting document, because there is reference to some of the problems produced by the war. Two important recommendations made by Secretary Lane in the report have to do with the returning soldier and the thorough Americanization of the many foreigners now living in the United States. Speaking of a fitting welcome to the returning soldiers, he says:

> What shall that welcome be? Is it to be merely one of glad greetings, the emotional outburst of a moment, or shall it take on a more permanent form, one which will be adequate in its largeness and lasting in its nature? Being Americans and being young, they will not ask or expect pensions. They will want work. They will want, if possible, a chance for a home of their own. Now, these hopes, reasonable and manly as they are, can be met in a fashion that will not weaken the fiber of the man by making him an object of bounty and that will add permanently to the strength and the wealth of the nation.

He would do this by making it possible for the returned soldier to obtain a home on land that now lies unutilized, such as swamp land, cut-over land left by logging operations and land needing irrigation to make it productive. There are in the United States at the present time at least 200,000,000 acres that can be converted into farms by irrigation, drainage or clearing, and if the Government undertook the work of making this vast area productive there would be no need of anxiety as to what to do with the returned soldier. Quoting the language of the report again:

> The energy and the talent which he has been expending for an ideal and $30 a month he can now use to make a home for himself. There would be laid before him a number of projects which the Government had undertaken in different sections of the country. Let us assume an irrigation scheme, a drainage project, and the development of a body of cut-over lands. The one would need to have great dams, a hydro-electric plant, miles of canal and tunnel, perhaps, thousands of acres to be cleared and leveled, fenced and broken. This would mean years of work at good wages, work in the open, and at the end a piece of land on which would be erected a house and barn, a farm home in a group of farm homes. For this he must pay. But already he has received wages out of which he can have saved the necessary first installment on his place of 10 or 15 per cent. The balance with interest he can pay in 40 yearly installments, or earlier if he can. If the life in Arizona is not to his liking, he can have the same opportunity after building the Arizona irrigated project to take up a farm upon another Government enterprise in South Carolina where men have drained the old rice swamps, or in Wisconsin on a tract of what once was swamp but has been converted into rolling prairie farms.

As to the cost of such an enterprise, the Secretary has this to say:

> How great will be the cost? As much as we wish to spend; as much as we need to spend. Less than many a strike has cost this country. Would it be unreasonable to ask for as much as we will spend this year for pensions to the veterans and their dependents of wars that ended 20 and 50 years ago? Would it be unreasonable to ask that we spend in the next two years on these veterans of the great war as much as it cost us to conduct that war for a single week? Would a people that gave out of hand, out of a noble sense of charity to quasi-public organizations, $500,000,000 for the entertainment and care of these boys, hesitate to buy the bonds of this country for a like amount to provide peace work, home work, and homes for these same boys? Canada with less than 7,000,000 people is offering to each man 160 acres of land and $2500 with which to improve it. Surely the United States, which has escaped with so slight a comparative loss in life, will not do less.

Regarding the pressing need of Americanizing the large numbers of foreign-speaking people in this country, Secretary Lane remarks:

> The draft revealed the astonishing percentage of those in this country who were unable to speak our language or to read or write any language. Yet there is no one thing so supremely essential in a government such as ours as that every man and woman and child shall know one tongue—that each may speak to every other and that all shall be informed. There can be neither national unity in ideals or in purpose unless there is some common method of communication through which may be conveyed the thought of the nation. All Americans must be taught to read and write and *think* in one language.
>
> What should be said of a democracy which sends an army to preach democracy wherein there was drafted out of the first 2,000,000 men a total of 200,000 men who could not read their orders or understand them when delivered, or read the letters sent them from home? What should be said of a democracy in which one of its sovereign states expends a grand total of $6 per year per child for sustaining its public-school system? What should be said of a democracy which is challenged by the world to prove the superiority of its system of government over those discarded, and yet is compelled to reach many millions of its people through papers printed in some foreign language? What should be said of a democracy which expends in a year twice as much for chewing gum as for schoolbooks, more for automobiles than for all primary and secondary education, and in which the average teacher's salary is less than that of the average day laborer? What should be said of a democracy which permits tens of thousands of its native-born children to be taught American history in a foreign language—the Declaration of Independence and Lincoln's Gettysburg speech in German and other tongues?

The Utilization of War-Time Coal

It is estimated that New England steam-coal consumers had in storage on Dec. 1, 1918, between four and five million tons of coal in excess of their supply on hand a year ago, according to a paper by Perry Barker, consulting fuel engineer, Boston, Mass., presented at the Boston meeting of the A. S. M. E. Mr. Barker pointed out that the source of coal supply for New England has not been materially different than in former years, but that the quality has been lower owing to the urgent need for increased production. The factors that affect the net utilization of coal for steam generation as expressed in the cost of evaporating a unit quantity of water are: (1) Cost per ton, including fixed price at the mine, freight and handling charges to the boiler furnace; (2) increased percentage of noncombustible; (3) increased percentage of volatile matter in fuel delivered to plants not having properly designed equipment for burning coal of such character; (4) decreased efficiency in burning coals not containing excessively high percentages of moisture, volatile matter or ash, but which have very low heating values due to "weathering" or heating in storage; (5) increased cost of evaporation due to poor efficiency and excessive labor and repair charges caused by using coal containing ash of a low fusing temperature.

The effect of increased percentages of ash is shown by the data presented in Tables I, II and III. These figures represent from 15 to 20 shipments of coal in each case and are typical fuels used by New England manufacturing companies. The average difference in heating value between the normal fuel and deliveries for the last year to a mill using low-volatile West Virginia coal was 3.6 per cent. This difference represents very nearly the actual decrease in evaporation per pound of coal, as the addition of this amount of impurities should have no material effect on the efficiency with which the coal is burned. The comparatively small change in quality of the fuel from this district is due to the fact that it is all subject to rigid inspection for navy and bunkering purposes.

The average of deliveries given in Tables II and III shows much greater increases in noncombustible material. These impurities increased the cost of delivering a unit of combustible to the point of consumption, affect the distribution of air in burning the coal, cause excessive loss of combustible in cleaning the fires and entail extra labor charge for handling the ashes.

It has been estimated that the average increase in impurities in fuel delivered is as high as 5 per cent., which would represent 1,250,000 tons of additional noncombustible that has been transported with the 25,000,000 tons supplied to New England this year. In one plant burning about 10,000 tons of coal per year, the cost due to handling ashes alone was increased to more than $2.50 per ton, which represented an additional charge of $3800 for the year.

Table IV shows the results of tests of three deliveries to plants normally using fuel of the quality given in column 1. The coal in column 2 was used in a hand-fired plant having return-tubular boilers with low settings. The firemen reported that the coal was "flashy" and made steam quickly, but with a firing interval of 20 to 30 minutes a large loss due to incomplete combustion resulted.

The figures in column 3 of Table IV illustrate a type of fuel that has been delivered to New England during the past year. This "outcrop" coal is loaded from seams that have been exposed and has lost a part of its combustible volatile matter. Coal of this character will not coke in the boiler furnaces, causing uneven distribution of air and excessive loss of combustible to the ashpits. The shipment of "outcrop" coal has been stopped by the Fuel Administration and about 200 mines responsible for such fuel have been closed.

The coal shown in column 4 of Table IV is of the most troublesome character, due to the low fusing temperature of the ash. It will be noticed that this figure is 430 deg. F. below the coal used prior to 1918. The low fusing temperature caused excessive clinkering, particularly at the high rates of combustion necessitated by the overloaded condition of the boilers.

TABLE I. WEST VIRGINIA LOW-VOLATILE COAL

	Normal Per Cent.	Average 1918, Per Cent.	High Ash 1918, Per Cent.
Moisture	2.50	3.11	2.48
Volatile matter	17.50	17.91	18.42
Fixed carbon	74.00	70.83	68.98
Ash	6.00	8.15	10.12
	100.00	100.00	100.00
Sulphur	0.65	0.63	0.73
B.t.u. per pound	14,410	13,886	13,656

TABLE II. PENNSYLVANIA LOW-VOLATILE COAL

	Normal Per Cent.	Average 1918, Per Cent.	High Ash 1918, Per Cent.
Moisture	2.50	4.74	6.82
Volatile matter	18.50	26.09	26.00
Fixed carbon	71.50	57.19	44.67
Ash	7.50	11.98	22.51
	100.00	100.00	100.00
Sulphur	1.40	1.12	1.47
B.t.u. per pound	14,125	12,554	10,047

TABLE III. PENNSYLVANIA STEAM SIZES OF ANTHRACITE

	Normal Per Cent.	Average 1918, Per Cent.	High Ash 1918, Per Cent.
Moisture	4.50	6.92	6.77
Volatile matter	5.00	5.74	4.40
Fixed carbon	74.50	67.12	57.50
Ash	16.00	20.22	31.33
	100.00	100.00	100.00
Sulphur	0.80	0.52	0.42
B.t.u. per pound	11,775	10,440	8,635

TABLE IV. TYPICAL CHANGES IN CHARACTER OF COAL FOR NEW ENGLAND STEAM PLANTS

	Normal Coal Per Cent.	War-Time Fuel Supply		
		Per Cent.	Per Cent.	Per Cent.
	1	2	3	4
Moisture	2.50	4.28	16.87	0.62
Volatile matter	18.50	34.12	28.00	19.36
Fixed carbon	71.50	47.16	44.50	67.90
Ash	7.50	14.44	10.63	12.12
	100.00	100.00	100.00	100.00
Sulphur	1.20	1.94	0.46	3.61
B.t.u. per pound	14,150	12,074	8,990	13,543
Fusing temperature	2550 deg. F.			2120 deg. F.

Electric Welding in Shipbuilding

On the evening of Dec. 30, Comfort A. Adams, president of the American Institute of Electrical Engineers, gave an interesting talk on "Electric Welding in Shipbuilding" before a joint meeting of the Chicago section of the society and the electrical section of the Western Society of Engineers. Mr. Adams outlined the activities of the committees of the American Institute of Electrical Engineers which had assisted in the development of electric welding practice in the shipbuilding industry. He compared briefly arc and spot welding, giving interesting data on the cost of the equipment, the electrical energy required and the strength of the welded joints. The speaker was optimistic as to the success of electric welding in shipbuilding. The savings over riveted construction are considerable. This is evidenced by the comparative cost figures for constructing American and English ships. At the present time the cost to American shipbuilders is about $200 per dead-weight ton, while the English yards have recently offered to produce all the ships America desires at a cost of $100 per dead-weight ton for the completed ship. As electric welding requires the use of less steel, produces vessels of less weight and hence a greater carrying capacity, and effects a considerable saving in labor, it offers an excellent opportunity for reducing the cost of ships made in America.

At a business session of the electrical engineering section of the Western Society of Engineers, during the evening the following officers were elected: Chairman, J. R. Cravath; vice chairman, Harold Almert; director for three years, M. M. Fowler.

Personal Mention

Osborn Monnett, who has just returned from Washington, where he has been serving as assistant advisory engineer, Bureau of Conservation, U. S. Fuel Administration, has opened offices at 1785 Old Colony Building, Chicago, for the practice of consulting engineering. He is specializing in combustion, boiler settings and general power plant problems. Mr. Monnett will be associated with the Commercial Testing and Engineering Co., chemists and coal specialists. The combination is a good one as the services rendered will fully cover all chemical and mechanical problems from the time the coal is purchased to the delivery of the energy at the switchboard. Mr. Monnett has had broad experience which should be invaluable in his new work. Formerly, he was consulting combustion engineer for the American Radiator Co., chief smoke inspector for the City of Chicago, associate editor of *Power*, and back of this he has had many years of practical experience in the operating steam engineering field, both stationary and marine.

Angus Sinclair

Angus Sinclair, D. E., founder and for the last 32 years editor-in-chief of *Railway and Locomotive Engineering*, died Jan. 1, 1919, at his home in Millburn, N. J. He was born at Forfar, Scotland, began his railroad career as a telegraph operator and learned engineering at the shops of the Scottish Northeastern Ry. at Arbroath. After some service as a marine engineer, he came to America and again took up railroading, first with the Erie, and later as a locomotive engineer on the Burlington, Cedar Rapids & Northern. He attended the chemistry classes of the Iowa State University and was later appointed chemist on the railway, combined with the duties of roundhouse foreman. It was during this period that he first gave serious attention to the problem of fuel economy and smoke prevention. His methods met with considerable opposition at first, but are now universally approved.

In 1883 he joined the editorial staff of the *American Machinist* and later became proprietor and editor of *Railway and Locomotive Engineering*. In a short time this paper became a leading authority in its field and has maintained its high character and standing ever since. Dr. Sinclair was the author of many popular books on engineering subjects. In 1908 he received the honorary degree of Doctor of Engineering from Purdue University. He was closely identified with the work of many of the leading engineering societies in America and with some of the same kind in Europe. He was elected a member of the American Railway Master Mechanics Association in 1873. He served as secretary of the association from 1887 to

1896, was elected treasurer in 1900 and served continuously until the time of his death. He became a member of the Master Car Builders' Association in 1873 and the American Society of Mechanical Engineers in 1883. He was the first president of the New Jersey Automobile and Motor Club. He was a delegate to the International Railway Congress held at Washington, D. C., St. Louis, Mo., and Berne, Switzerland.

Among the societies which he aided in establishing was the Traveling Engineers Association, founded in his office in 1892. He was a Knight Templar in the Masonic fraternity, a governor in the St. Andrew's Society, ex-president of the Burns Society and also of the St. Andrew's Society of Newark, besides being a member of the American Railway Guild, Lawyers Club, New York Railroad Club, and numerous other railway, Scottish and other societies.

New England Fuel Crisis Ended: Mr. Storrow Resigns Post

James J. Storrow of Boston, Federal Fuel Administrator for New England, has offered his resignation to Dr. Garfield with the statement that both hard and soft coal conditions are now satisfactory. Mr. Storrow stated in announcing his resignation that for several weeks New England has been well stocked with soft coal and needed no further attention on his part. The domestic hard coal situation is now satisfactory and can safely be left to the regular trade channels to carry the market through the balance of the winter.

From Apr. 1 to Dec. 1, 1918, New England received 20,187,670 tons of soft coal as compared with 16,469,866 tons in the corresponding period of 1917. The conservation work is estimated to have saved New England at least a million tons of coal, and in addition a large increase has been brought in in the steam sizes of anthracite. Mr. Storrow said that counting all these factors, the steam-coal users of New England are 33 per cent. better off this year than a year ago. More soft coal could have been brought in during the past thirty days if needed, but the district is now thoroughly supplied and from now on will need considerably less than normal current shipments. During the entire twelve months of the coal year which ended Apr. 1, 1917, the last practically normal year, New England received 9,893,000 net tons of domestic sizes of hard coal. During the first eight months of the present coal year 8,108,000 tons have been received. As a result of this large increase in the movement of hard coal into New England, aided by the mild weather and the coöperation of householders in conserving fuel, domestic users can now look forward without fear of any repetition of the experience of a year ago. Mr. Storrow said:

> New England owes a debt of gratitude to Harry A. Garfield, a man of high moral purpose, eager to stand fast for the right. When he saw that New England, due to the long distance from the mines, the tremendous war pressure of our industries, the blockading of our railroads, the loss of our tugs, the taking of our colliers and the difficulties of winter movement along the coast, must be given an offsetting consideration, he never hesitated to go to the point where he felt the equilibrium of equal justice for all sections was established. Beyond this we believe we never asked him to go. Beyond this his character made it impossible for him to go.
>
> At the very worst and most critical day of last winter's danger and distress William G. McAdoo was appointed director general of railways. On Sunday afternoon, at his home, within forty-eight hours of his appointment, he gave us effective aid. If this had not come on that day, New England would have been in a plight which, fortunately, no one but the New England fuel administrator, sitting in his office, to which all the threads from all New England ran, could know, and which, indeed, we think New England can never know or realize.
>
> The local fuel committee of Massachusetts has performed a signal public service. The work has been anxious and laborious. Our Massachusetts cities and towns were face to face with one of the most menacing situations ever encounterd in their history. I believe every state in the Union outside of Massachusetts contented itself with merely a county administrator We reached down into every town and city, where a hard working chairman and an efficient committee have done their community patriotic public service probably but little understood, but without which there would have been great anxiety and distress. If the Massachusetts administration had not rested on the firm basis provided by these 312 chairmen and committees, our efforts would have been largely unavailing and quite ineffective. May I say that it has been to me a great satisfaction and pride to be working with such a body of men? As I have come to know them, to realize the unselfish way in which they have assumed their hard task, how they kept their heads during anxious days, what sound judgment they have over and over displayed, and how they have commanded the respect and confidence of their communities, I have said to myself, "These men are the pith and sinew of New England. They are the kind of men who have made the proud and successful history of this comparatively bleak and sterile little corner of this great country."

Professor Rateau Honored

Professor Auguste C. E. Rateau, inventor of the Rateau turbine, has been named a member of the Académie des Sciences. The recipient of this well-deserved honor was born in 1865. He was authorized by the French government, at the age of 18, to compete for admission to the École Polytechnique of Paris. This authorization was necessary on account of his being under age for such a competition. He was admitted and left the school after the examination carrying the number "one." This honor is held very high in France and is very dear to Professor Rateau. From this school were graduated Joffre, Foch, Castelnau and Petain. Professor Rateau then went to the École Supérieure des Mines, where he followed the post-graduate course, and, at the age of 23, was named professor of higher mathematics at the École des Mines at St. Etienne. Later on he was named professor in the École des Mines de Paris, where he held in succession all the chairs referring to mathematics, mechanics and electricity.

Some twenty-five years ago Professor Rateau completed tests on the flow of steam and investigated the technical problems involved in the design of steam turbines. He patented the resulting designs and placed on the market the type of steam turbine bearing his name. This type of machine has been adopted partly or entirely by practically all of the manufacturers in this country and abroad.

Rateau was the first to realize the great savings to be obtained by the use of low-pressure steam in turbines. His inventions and designs in this field are steam regenerators, permitting the use of intermittent exhaust steam from reversing engines to be used in condensing steam turbines, mixed-pressure turbines, turbine regulators, etc. There are over two million horsepower of steam regenerators in this country and abroad, and over three million horsepower of mixed-pressure turbines.

The work of Professor Rateau on the theory, design and operation of rotary fans and pumps is well known. He was the first to develop the centrifugal turbo-compressor. The first hundred-pound compressor was built by him in 1889. These machines have since come into general use, many being used in steel works and copper works, to produce the blast for blast furnaces, converters, smelters, etc.

In naval work Professor Rateau has done a great deal, and a number of battleships, destroyers, torpedo boats, etc., are equipped with his machines. In this country three electrically driven tank boats of the Mexican Petroleum Co. are equipped with Rateau turbines. Among the firms manufacturing in this country under Rateau licenses are Westinghouse Electric and Manufacturing Co., General Electric Co., Ingersoll Rand Co., Ridgway Dynamo and Engine Co., Southwark Foundry and Machine Co. and Terry Turbine Co.; in Canada, the Dominion Bridge Co.; in England, Fraser & Chalmers Co., British Westinghouse Co. and Adamson & Son.

In airplane work Professor Rateau has not been idle. He has studied the resistance of planes in the air, and during the war designed and placed in operation, on board airplanes, an apparatus which has not yet been disclosed to the public, which gave new possibilities in airplane propulsion.

As an industrial, Professor Rateau is the founder of the Société Rateau in Paris, having shops in France and Belgium. He has always been directly connected and associated with the Rateau Steam Regenerator Co. and the Rateau Battu Smoot Co. in this country.

The hydro-electric works at Lake Coleridge, New Zealand, have been so successful that not only is the Government convinced by their success of the practicability of developing other schemes, but the general public is prepared to press the authorities to proceed with the large program which has been drawn up. The program provides for a series of schemes designed to supply the whole of the North Island with hydro-electric power from three sources, eventually to be linked together. The Chief Electrical Engineer to the Government, in a report on the possible development of hydro-electric schemes in the North Island, suggested the utilization of waters of the Mangahao River, the Waikato River and Lake Waikaremoana; the first to supply the southeast and southwest, the second the center and northwest, and the third the northeast of the North Island. It was suggested that the first two should be proceeded with at the earliest possible moment, and that the third should be deferred until railway communication in the Hawkes Bay and Poverty Bay districts had been improved.—*The Engineer.*

New Publications

ELECTRICAL BLUE BOOK.—Published by the International Trade Press, Inc., Chicago, Ill. 1918. Cloth, 9 x 12 in.; 274 pages; Illustrated. Price, $2.

This book, which has become so well known to those in the electrical industry, is now published in its eighth edition. The text is divided into seven parts: Catalog Exhibits of Electrical Apparatus and Materials; List of Underwriters' Laboratories, Branch Offices and Inspection Stations; List of Inspected Electrical Apparatus and Material, as examined and approved by the National Board of Fire Underwriters, up to Apr. 1, 1918; The National Electrical Code, Explained and Illustrated; List of Members of the Electrical Supply Jobbers' Association; Directory of Electrical Associations; and Complete Buyers' Guide of Electrical Apparatus and Material. The National Electrical Code for 1918 is published in full, with explanatory notes and illustrations showing simple and practical methods for fulfilling these official requirements. The Book as a whole is a comprehensive source of practical electrical information as well as a buyers' encyclopedia.

Obituary

John E. Williams, formerly fuel administrator for Illinois, and widely known as an arbitrator in industrial disputes, died at his home in Streator, Ill., on Jan. 2, after an illness of several months. In addition to his duties as fuel administrator, he was United States administrator for the packing industry and labor arbitrator for Hart, Schaffner & Marx. He was 65 years old. He is survived only by his widow.

Personals

Lieut. Louis O. Monroe has returned to the Clarage Fan Co., Kalamazoo, Mich., as manager of sales and chief engineer. Mr. Monroe was in charge of the Chicago office of the company before entering the service.

C. W. Bell, formerly assistant chief engineer, Hauto Power Station, Lehigh Navigation Electric Co., is now superintendent of power plants, Northumberland County (Penn.) Gas and Electric Co. and the Columbia and Montour Electric Co.

W. L. Bigelow is now Eastern salesman for the Sanford Riley Stoker Co., of Worcester, Mass., and the Murphy Iron Works of Detroit, Mich., directing sales and services of the Riley underfeed stoker and the Murphy automatic furnace, with offices at 1226 Woolworth Building, New York City.

Engineering Affairs

The American Society of Heating and Ventilating Engineers will hold its annual meeting in New York City, Jan. 28-30.

The Marine Engineers' Beneficial Association will hold its annual convention at Buffalo, N. Y., during the week beginning Jan. 20. The Hotel Statler is the headquarters.

The American Society of Mechanical Engineers announces that the following sections will hold meetings: At the Engineers' Club, Philadelphia, Jan. 28; at the Hotel Statler, Buffalo, N. Y., Jan. 29.

Business Items

The Vanadium-Alloys Steel Co., of Pittsburgh, Penn., has leased offices and warerooms at 566-568 West Randolph St., Chicago, in order to carry a larger stock to meet the growing demands of customers in this territory.

The Penberthy Injector Co. has produced its one-millionth injector. In days when the talk is in billions, a million makes little impression. Yet, it is one thousand thousands. Hence, for the 30 years during which the Penberthy company has been manufacturing injectors the average production was about 3000 per month. Something like 6,000,000 lb. of copper was melted to make them and they would feed 50,000,000 boiler horsepower. The Penberthy company began to make injectors in 1886 at Detroit, Mich., in a one-room plant of about 144 sq.ft. of floor space and equipped with one small lathe. Today, the company's plant covers 2½ acres and is one of the best-known and equipped in the high-grade brass specialty field.

Trade Catalogs

The Hess-Bright Manufacturing Co., of Philadelphia, has issued a 108-page catalog (Form 881) entitled "The History and Development of Ball Bearings." It is fully illustrated, contains numerous tables and much useful information.

A. S. Cameron Steam Pump Works, 11 Broadway, New York, have issued a twelve (12) page bulletin on pumps for marine service. This bulletin shows sectional and complete views, as well as description and tables, that will be of service to anyone interested in the subject of marine pumps.

New Construction

PROPOSED WORK

Conn., Bridgeport—The city plans to build Black Rock intercepting sewer and laterals and an auxiliary pumping station at Harborview Ave. and Gilman St. Estimated cost, $160,000. J. A. McElroy, City Engr.

Mass., New Bedford—The Whitman Mills Corporation, Coffin Ave., plans to build a 1-story. 12 x 30 ft. transformer house. Z. B. Davis, Corporation, 668 Acushnet Ave., Arch.

Conn., Hartford—S. Z. Pole, 24 Church St., New Haven, will install a steam heating system in the 3-story, 120 x 158 theater which he plans to build on Main St. Total estimated cost, $125,000. T. W. Lamb, 644 8th Ave., New York City, Arch.

N. Y., Cohoes—The Board of Education will install a steam heating system in the 2-story high school building which it plans to construct in the spring. Total estimated cost, $210,000. Tooker & Marsh, 101 Park Ave., New York City, N. Y., Engr.

N. Y., Fulton—The Oswego Falls Pulp & Paper Co. plans to install a heating and ventilating system in its plant. Estimated cost, $40,000. Elmer E. Palmer, Snow Bldg., Syracuse, Consultg. Engr.

N. Y., Ithaca—The Ithaca Traction Co., 113 East State St., plans to rebuild its power house recently destroyed by fire, entailing a loss of $75,000.

N. Y., Little Falls—H. P. Snyder Manufacturing Co. plans to remodel its heating, ventilating and power plant. Estimated cost, $10,000. Elmer E. Palmer, Snow Bldg., Syracuse, Consultg. Engr.

N. Y., Long Island City—The White Co., Park Ave. and 57th St., New York City, will install a steam heating system in the 1½-story, 200 x 600 ft. factory building which it plans to construct on Thompson, Nott, Mound and School St. Total estimated cost, $500,000. Watson Engineering Co., 1101 Hippodrome Bldg., Cleveland, Ohio, Engr.

N. Y., Rockaway—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until January 20, for the construction of a heating plant in the Navy Yard here. C. W. Parks, Chief.

N. Y., South Colton—The Aluminum Co. of America, Oliver Bldg., Pittsburgh, Penn., has purchased flowage rights and site at Three Falls Power, just above here and plans development.

N. Y., Stark—The Aluminum Co. of America, Oliver Bldg., Pittsburgh, Penn., plans to develop the power on the Racquette River.

N. Y., Utica—The State Hospital Commission, Capitol, Albany, will soon receive bids for installing boilers, piping, etc., in the Utica State Hospital. Estimated cost, $75,000.

N. J., Asbury Park—The First Methodist Episcopal Congregation plans to install a steam heating system in the 2-story, 70 x 190 ft. church which it plans to build. Total estimated cost, $150,000. Lucian E. Smith, 2 West 47th St., New York City, N. Y., Arch.

Md., New Windsor—The B. F. Shriver Co. is having plans prepared by J. F. Roystone Engineering Co., Times Bldg., Westminister, for the construction of power house and canning factory.

Ga., Atlanta—R. C. Turner, City Electrician, recommended that city build an electric plant for the purpose of utilizing the steam which is going to waste at the crematory. Estimated cost, $70,000. H. L. Collier, City Engr.

Tenn., Bristol—A. L. Womack & Co. plans to build a refrigerating plant in connection with the poultry plant which it plans to construct.

Tenn., Memphis—The City Commission will soon award the contract for the installation of a heating plant at the North Memphis pumping station.

Ohio, Ashtabula—The city plans to double the capacity of its lighting plant. Plans include the installation of another 1000 h.p. boiler as well as some minor equipment.

Ohio, Sulphur Springs—The Central Power Co., Canton, plans to extend its mains from the line north of Sulphur Springs where the new main will cut across from New Washington to Crestline, into the city to serve the people. F. H. Golding, Canton, Gen. Mgr.

Ind., Richmond—The Board of Public Works, City Hall, plans to improve the hydroelectric light plant. D. B. Davis, City Engr.

Mich., Ford (Wyandotte P. O.)—The village is in the market for an 8-in. pump having a capacity of 4000 gallons per minute, driven by a 25 hp. gasoline engine as auxiliary, to be installed in the ewerage pumping station. M. L. Brown & Son, 871 Chamber of Commerce Bldg., Detroit, Engr.

Mich., Grand Rapids—The Dominican Sisters plan to install a steam heating plant in the 4-story convent which they plan to build. Total estimated cost, $300,000. E. Brielmaier & Sons, 111 Mason St., Milwaukee, Wis., Arch.

Ill., Chicago—The Kercher Hotel & Bath Co., 505 South Wabash Ave., plans to install a high pressure steam heating system in the 12-story, 80 x 170 ft. hotel which it plans to build at 414 South Wabash Ave. Total estimated cost will run over $1,000,000. Walter W. Ahlschlager, 133 West Washington St., Arch.

Ill., Springfield—The city voted a $60,000 bond issue for the construction of a lighting system in the business centre and down town section. Wade Seeley, City Engr.

Wis., Milwaukee—The Robert A. Johnston Co., 270 Florida Ave., plans to install a steam heating system in the 7-story, 135 x 310 ft. candy and biscuit factory which it will build on National Ave. and 34th St. Plans include the construction of a power house. Total estimated cost, $500,000. H. J. Esser, 402 Camp Bldg., Arch.

Wis., Oconto Falls—Frank F. Becker and C. H. Hartley plan to build a hydroelectric plant and dam between Oconto Falls and Gillett. Mead & Seastone, Madison, Engr.

Wis., Prairie Du Chien—The Mid-Continental Utilities has applied to the City Council for a franchise to build transmission line from the city limits to the power plant. C. Grelle, Pres.

Minn., Hibbing—The village plans to build an electric light and power plant. Estimated cost, $500,000. Charles Foster, Mgr.

S. D., Beresford—C. H. Green has applied to the City Council for a franchise to build an electric light plant.

S. D. Burke—The city voted a bond issue for the construction of an electric light plant.

Wyo., Sheridan—The Sheridan County Electric Power Co., controlled by the Federal Light & Traction Co., plans to improve its local plant. Judson Hibbs, Mgr.

Mo., Kansas City—Swift & Co., Union Stock Yards, Chicago, Ill., will soon award the contract for the construction of a 3-story, 75 x 100 ft. addition to its boiler house on Adams and Berger St. S. A. Middaugh, Purchasing Agent.

Mo., Macon—Frank L. Wilcox, Engr., Syndicate Trade Bldg., St. Louis, made examinations and submitted report to the City Council recommending the following improvements to the electric light plant: The installation of unaflow engine, 125 lbs. steam pressure, 26 vacuum, 164 r.p.m., direct connected to 350-400 k.v.a. generator with belted exciter, $27,500; above unit delivered and erected complete, including foundation, piping connections and electrical connections, the said piping connections to include steam and exhaust pipe, suction and discharge piping for condenser with atmospheric exhaust stack, automatic relief valve, exhaust head, steam separator, trap and oil separator with necessary valves and fittings, $35,000; surface condenser for 250-400 k.v.a. unit with combination circulating and vacuum pump, including spray system, cast iron piping and connections for same, delivered and erected ready for, but not including steam exhaust, suction and discharge piping (same being included in above $35,000 item) $6,350; combination exciter and voltage regulator panel, $750; concrete spray pond 60 x 80, 120 cu.yds. Reinforced concrete at $21, $2,520; other incidentals bringing total cost to $55,000.

Mo., Richmond—The City Council plans to install 2 new boilers and other machinery in the water-works.

Mo., St. Louis—The Hussmann Refrigerator Co., 911 North Broadway, will install steam heating plant, sprinkler system and electric motors in the 1-story, 130 x 200 ft. factory which it plans to build on Leffingwell Ave. and North Market St. Total estimated cost, $50,000.

Tex., Cisco—The Cisco Gas & Electric Co. plans to remodel its plant and build power and ice plants.

Tex., McAllen—The Rio Grande Public Service Corporation plans to improve and enlarge the electric light plant, water system, and ice plant. Plans include the installation of machinery which will more than double the present capacity.

Okla., Covington—The city plans an election to vote on a $40,000 bond issue for the installation of an electric plant, waterworks and sewerage system. Address the Mayor.

Colo., Denver—The Cities Service Co., 60 Wall St., New York City, N. Y., has purchased the controlling interest in the Western Light & Power Co. and plans improvements. Equipment to cost $1,250,000 will be installed in same. Frank W. Frueauff, New York, Vice Pres.

Utah, Ogden—The city plans to build a power and light plant. Estimated cost $500,000. J. M. Tracy, City Engr.

Cal., Calexico—The City Trustees plan to build an electric-light and power plant.

Que., Verdun—J. P. Dupuis, 592 Church St., is in the market for a sawmill with 60 to 70 h.p. engine.

Ont., Alvinston—The Hydroelectric Commission of Ontario, University Ave., Toronto, plans to remodel the electric light plant here. Estimated cost, $40,000. F. A. Gaby, Engr.

Ont., Goderich—The National Shipbuilding Co. is in the market for a 6 ft. radial drill for boiler shop; lathe to take in 12 ft. between centers; air hoists 10 in. cylinder, 4 ft. lift with trolley; vertical air receiver, 44 in. inside diameter by 14 ft. high.

Ont., Owen Sound—The North American Bent Chair Co. is in the market for several electric motors.

Ont., Smith Falls — The Hydroelectric Power Commission plans to install two 1000 imperial gallon centrifugal pumps and one 800 imperial gallon booster pump for the water system, both to be electrically driven by hydro power.

B. C., New Westminster—The New Westminster Co-Operative Association plans to build a cold-storage plant. Estimated cost, $70,000.

B. C., Vancouver—The Pacific Great Eastern Railway Co. plans to develop electric power along its line in the province. George L. Courtney, Gen. Mgr.

CONTRACTS AWARDED

Vt., Bellows Falls—The Bellows Falls Power Co., c/o Charles Harriman, Inc., 50 Congress St., Boston, Mass., has awarded the contract for the construction of a hydroelectre plant on Bridge St., to the Power Construction Co., 35 Harvard St., Worcester, Mass.

Mass., Chatham—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a boiler house, heating system, etc., here, to Coleman Bros., Chelsea.

N. Y., Thiells — L. F. Pilcher, State Architect, has awarded the contract for installing a heating plant in the attendants home and service building, at Letchworth Village, to Miller-Grady, 210 East 38th St., New York City, $4477; electric work, to the W. H. Strant Co., 14 New Main St., Haverstraw, $2000.

N. J., North Bergen—The Board of Education has awarded the contract for installing a heating and ventilating system in P. S. No. 7, to Edward Beck, 716 Bergenline Ave., West New York. Estimated cost, $8148.

Penn., Pottsville—Bernard Schmidt, 13th and Walnut St., has awarded the contract for the construction of a 1-story, 134 x 134 ft. bakery to include a boiler house, to E. N. Lebo, 1922 Berryhill St., Harrisburg. Estimated cost, $30,000.

Wis., Manitowoc—The Burger Boat Co. has awarded the contract for installing motor and power transmission equipment, including a 185 h.p. motor, to the L. J. Anderson Electric Co.

Mo., St. Joseph—Swift & Co., Union Stock Yards, Chicago, Ill., has awarded the contract for the construction of a 3-story, 51 x 52 ft. addition to its power house, to the Lehr Construction Co., 1712 Frederick Ave. Estimated cost, $40,000.

Cal., Martinez—The city received lowest bid for furnishing pumping and electrical equipment for the water-system, from Fairbanks-Morse Co., 651 Mission St. San Francisco, at $6015.

Cal., San Pedro—The Union Ice Co., 660 South Alameda St., Los Angeles, has awarded the contract for the construction of a 1-story, 50 x 100 ft. cold storage and ice making plant on Mesa Ave., to C. M. Gray & Sons, 2650 Santa Fe Ave. Estimated cost, including equipment, $30,000.

Que., Temiskaming—The Kippewa Fibré Co. has awarded the contract for the construction of twenty 1-story, concrete buildings to be used as sulphite paper mills, to George A. Fuller Co., 45 St. Alexander St., Montreal. A steam heating system will be installed in same. Total estimated cost, $3,000,000.

B. C., Vancouver—The Foundation Co., Ltd., has awarded the contract for furnishing marine boilers, to the Vulcan Iron Works, Granville Island. Estimated cost, $1,000,000.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.6
Rice	2.90	Barley	2.4

All rail rate to Boston is $2.80

BITUMINOUS

Bituminous $8 to $8.75

Pocahontas and New River, f.o.b. Boston $8.35 to $8.90

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individua
Pea	$6.55	$7.30	Broken	$7.80	$8.5
Buck	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.8

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows.

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields.		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.15	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10 other rates p. 95.

POWER

Volume 49 New York, January 21, 1919 *Number* 3

No steam-plant owner would permit his money to be burned up in this fashion—

Yet there are many who view this state of affairs with complacency.

REBUILDING 25,000-KW. GENERATOR

By *Thomas Wilson*

A MOST interesting and difficult piece of work that required turning the generator to a vertical position to receive the new laminations was greatly complicated by the fact that the machine, whose total weight exceeds 200 tons, had to be up-ended within the space of its own foundation, which necessitated raising it a distance of 4½ ft. before turning it.

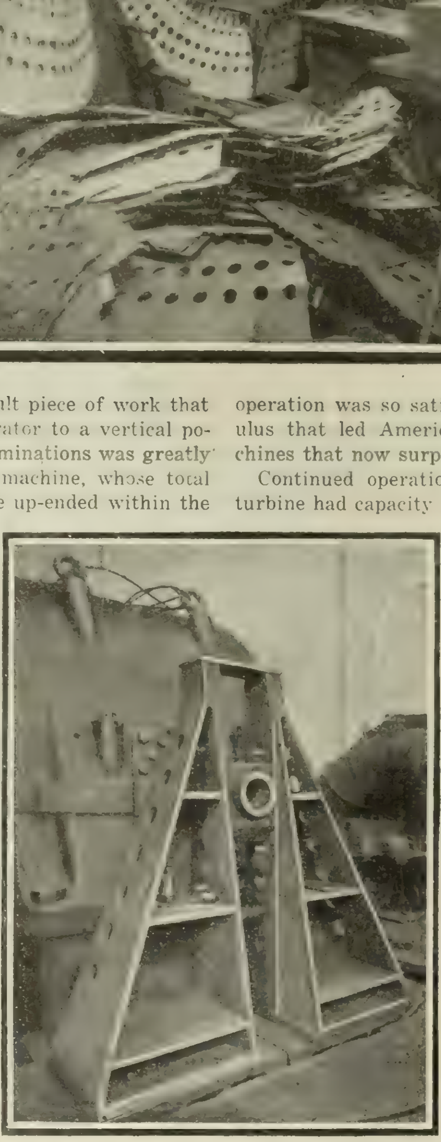
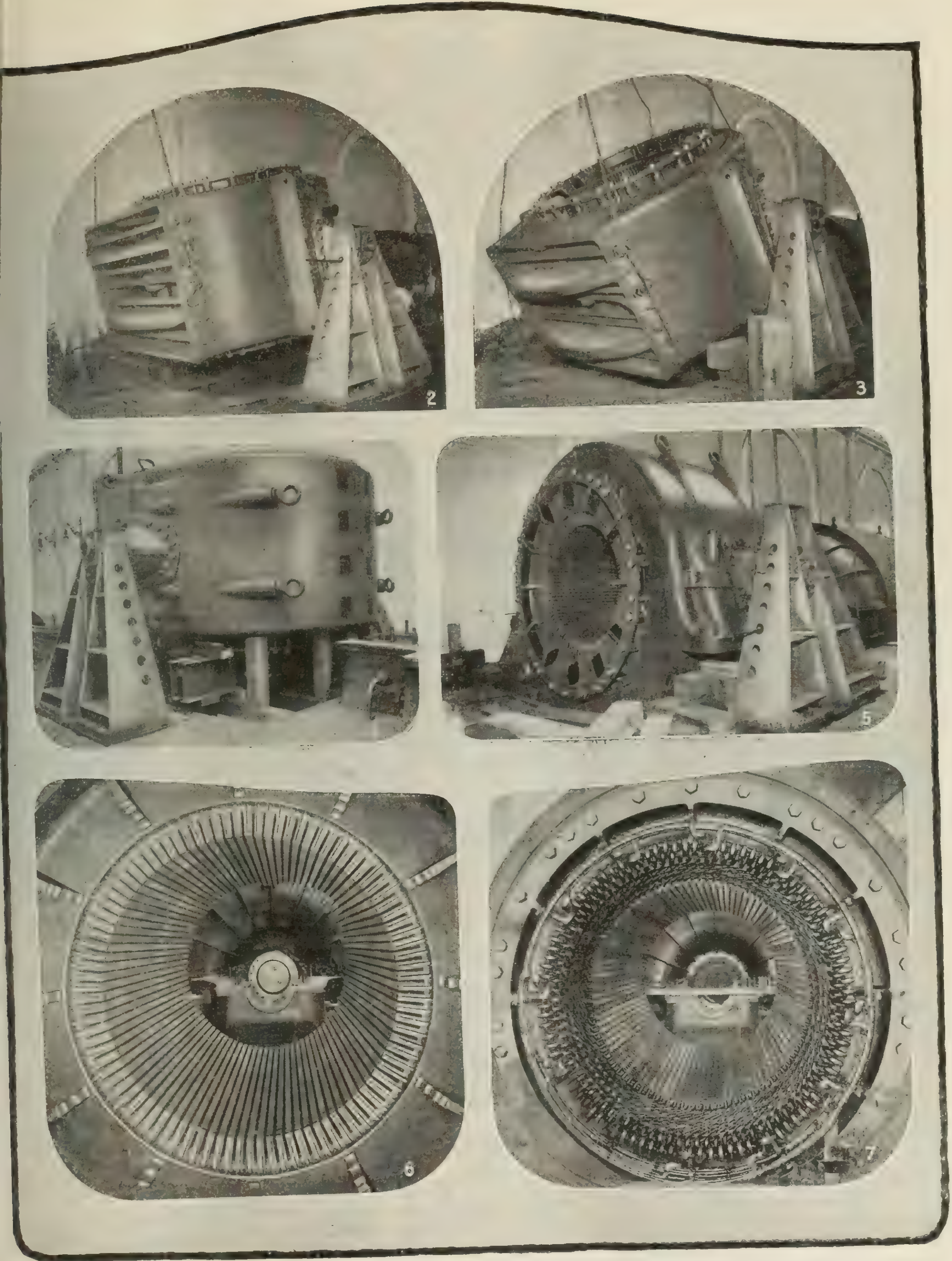


FIG. 1. A-FRAME PEDESTAL AND TRUNNION BOLTED TO SHELL OF GENERATOR

Readers of *Power* will remember that early in 1914 the English Parsons unit for the Commonwealth Edison Co., of Chicago, was put into commission in Fisk Street Station. At the time the unit created marked interest for two reasons—the generator was the largest that had been built, and the steam-rate guarantee was the lowest ever offered. It was rated at 25,000 kw. and at four-fifths load was designed to deliver a kilowatt-hour on 11.25 lb. of steam, based on steam conditions of 200-lb. gage and 200 deg. F. superheat at the throttle, and an absolute back pressure equivalent to 1 in. of mercury. In practice the turbine is reported to have bettered the guarantee. and its operation was so satisfactory, that it provided a stimulus that led American manufacturers to design machines that now surpass the record of this unit.

Continued operation brought out the fact that the turbine had capacity in excess of rating, the indications being that it was capable of developing 30,000 kw. The urgent necessity for additional generating capacity and of a higher efficiency than that to be obtained from the older generators in the station made it advisable to utilize the full power of the turbine by providing it with a larger and more efficient generator. Whether to install a new 30,000-kw. generator or to rewind the older one for that capacity was an interesting problem, which was finally decided in favor of the latter alternative. The two prime factors affecting the decision were time and cost. With the electrical industries crowded with war work and transportation facilities overloaded, prompt delivery of a new machine could not be expected. Current quotations for a generator of this size were nearly double those of 1914, so that

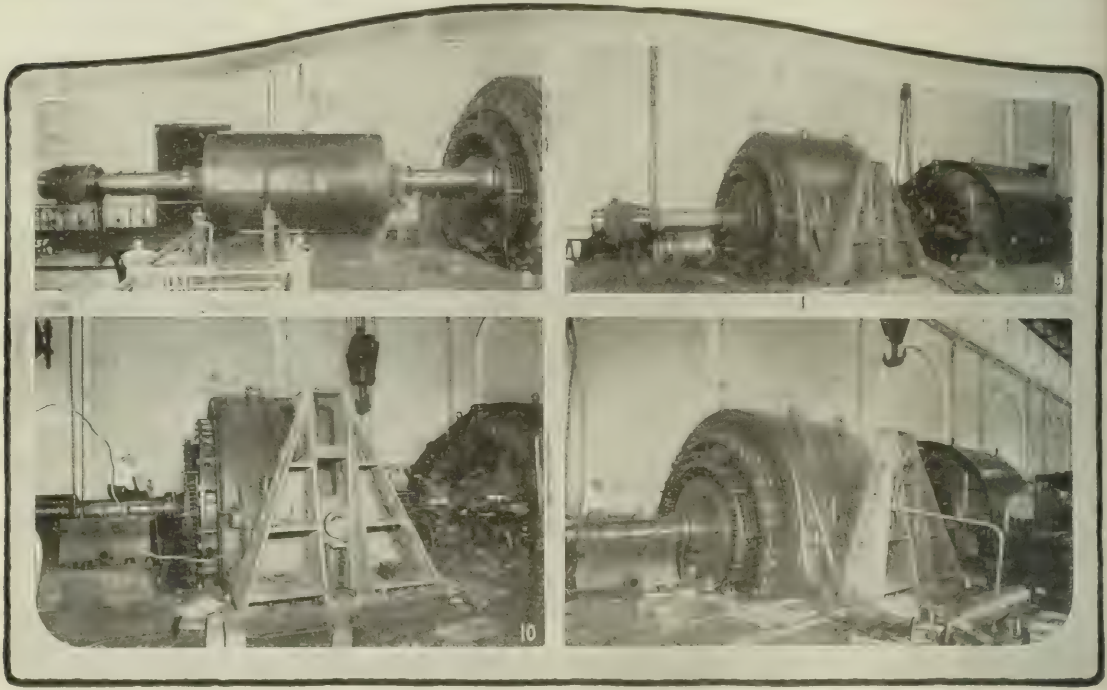


FIGS 2 TO 7 VIEWS OF HOW MACHINE WAS HANDLED WHEN BEING REBUILT

Fig. 2—Turning armature to vertical position. Fig. 3—Armature being turned back to horizontal position with laminations and clamping rings in place. Fig. 4—Armature blocked in place ready for restacking. Fig. 5—Lowering armature one side at a time. Fig. 6—Looking through armature at central bearing of unit. Fig. 7—Armature windings in place.

here also it was estimated that the advantage lay in favor of revamping the old machine, and as a matter of fact the cost per kilowatt of increased capacity proved to be less than the unit price for a new machine.

To rebuild a generator of this size with the facilities available in the plant proved to be a very interesting task, but also a difficult one. The contract was accepted by the General Electric Co., with the stipulation that the handling and placing of the machine was to be done by the Commonwealth Edison Co. The method of procedure was suggested by the engineers of the General Electric Co. and was worked out by the engineering department of the operating company, who designed the handling rig and arranged for providing the necessary equipment. The execution of the work was carried out under the supervision of this department, and the General Electric Co. supplied the necessary men familiar with this class of work.



FIGS. 8 TO 11. DIFFERENT OPERATIONS IN THE REASSEMBLING OF THE ALTERNATOR
Fig. 8—Moving field into armature. Fig. 9—Field in position, machine ready to lower. Fig. 10—Oil jacks supporting armature. Fig. 11—Generator lowered on its foundation

As is common with large units, the generator is of the revolving-field type. It was originally a three-phase 25-cycle 4500-volt machine delivering through auto-transformers to a 9000-volt bus. The armature was of the closed-slot type and the frame was split on the horizontal diameter. The new design called for a 9000-volt generator delivering directly to the bus, for a frame in one piece, open armature slots and a different arrangement of ventilating ducts. A noteworthy feature is that the General Electric Co.'s engineers were able to so design the rebuilding of the armature that the revolving field required no remodeling, and the direct-connected exciter required only to have its field rewound.

To rebuild the armature it was necessary to take off the top half of the frame, remove the field and tear out the armature windings and the laminations. The headpiece shows the general outline of the laminations and the openings in them for ventilation and gives some indication of the immense number that had to be handled. The total weight of these stampings was over 58 tons, and in addition to them eight tons of copper and two tons of brass were also removed.

As the initial step in the reconstruction work the top part of the armature casting was refitted to the bottom half of the frame and secured by dowel pins and additional bolts. A cast-steel ring on each end, secured to the frame by twenty-eight 2½-in. bolts, served to bind the two halves more firmly and hold the new laminations in position. To place and secure the latter, new dovetail strips on the inner surface of the frame were essential.

Before the new iron could be stacked in the armature, it was necessary to turn the frame on end, and owing to limitations in floor space this had to be done on the generator's own foundation. The shape of the casting was such that, to obtain clearance for turning it, the frame had to be raised 4½ ft. above the foundation.

The turbine room is equipped with two traveling cranes, one rated at 50 tons and the other at 60 tons; of these only one could be brought into play during the greater part of the work. The weight of the armature with the new laminations in place was estimated at 132 tons and it was therefore necessary to provide a special rig on which to turn the frame from the horizontal to the vertical position and back again. This consisted of two double-A-frame pedestals, one of which is clearly shown in Fig. 1, the other being in position at the opposite side of the generator. The vertical legs were proided with holes at various distances above the base for . 4-in. steel pin to carry a bearing block through which n turn passed the journal of a cast-steel trunnion that ad been bolted to the frame of the machine. At the loor level these pedestals were bolted to cast-iron brackets rigidly secured to the cast-iron foundation of the generator. The pedestals and the supporting brackets weighed 16 tons, and the trunnions one ton each. The atter were secured to the frame by 22 two-inch steel bolts, and back of them inside of the frame were placed reinforcing plates to distribute the strain as much as possible. The metal of the legs through which the pins passed was 3 in. thick. To insure a fair bearing for he immense weight to be supported the holes were carefully ground.

When the empty shell of the generator, weighing 62 .ons, was ready to be turned, it was raised to an elevation of 4 ft. 6 in. above the floor by the 60-ton crane. The supporting pins were then inserted in the pedestals under the bearing blocks, and the frame was turned on the trunnions to a vertical position by means of one of the cranes, which had been hitched to the bottom of the casting, as shown in Fig. 2. As indicated in Fig. 4, it was then held in this position by heavy timbering and blocking. The new laminations were placed and pressed into position in the usual manner. Including the spacing blocks, bolts, etc., the new iron added 70 tons to the weight of the frame, making a total weight of 132 tons to be supported by the pedestals. Later the armature windings, consisting of 96 coils, which were placed when the armature was turned back to the horizontal position, added another 6½ tons, so that the total weight of the armature exceeded 138 tons.

LOWERING THE FRAME ONE SIDE AT A TIME

When the stampings were in place, the frame was again turned on the trunnions until it once more occupied a horizontal position, the crane being used for this operation, as shown in Fig. 3. As its weight was now 132 tons, or double the capacity of the larger crane, the frame had to be lowered one side at a time. The crane was hitched to one trunnion, taking one-half the weight of the machine. The pin on that side was removed and transferred to the next hole, 9 in. below, and the machine was lowered until the trunnion bearing block rested on it. The operation is indicated in Fig. 5. The hitch was then changed to the opposite side, the frame being lowered in the same way, first to a level position and then to one step below. Alternate transfers were made until the stator was lowered to within 15 in. of the floor. Blocking of this height had been provided and the frame was lowered upon it, thus releasing the pins under the bearing blocks from service and allowing their removal. A stop at this elevation was necessary in order that the coupling on the shaft of the revolving field would pass over the center bearing of the unit when the field was later replaced within the armature. This will be made clear from an inspection of Fig. 6. With the frame in this position the armature windings were put into place, whereupon it appeared as in Fig. 7.

The insertion of the field was the next step. It is 6 ft. in diameter, the over-all length of its shaft is 29 ft. and its aggregate weight 65 tons. Fig. 8 shows the rotor as it appeared suspended from the 60-ton crane preparatory to being inserted into the armature. It was carefully guided into the armature bore as far as the hitch would allow, which, as had been determined by previous calculation, was enough to permit the coupling to project on the other side of the frame. It was then blocked temporarily while the 60-ton crane was being transferred to the coupling end of the shaft and the 50-ton crane hitched to the exciter end. With the two cranes in use the rotor was carried through into its proper position within the armature. At this stage the machine appeared as shown in Fig. 9. After the outboard bearing had been slid into place, the reassembled generator was ready to be lowered the remaining 15 in. to its foundation.

LOWERING THE GENERATOR TO ITS FOUNDATION

Although the distance was small, this task was the most difficult of the entire operation, requiring delicate manipulation of the facilities at hand. The blocking upon which the frame was resting consisted of pieces one and two inches in thickness. By placing an oil jack under each trunnion bearing block, as shown in Fig. 10, the weight on the blocking was relieved and it was removed piece by piece as the frame was lowered by means of the jacks. The downward movement of the armature, now weighing 138 tons, was thus under complete control and could be effected very gradually. It was necessary to coördinate this operation with the lowering of the revolving element by the cranes. As the 1-in. air gap between the stator and the rotor gave a maximum clearance of only 2 in., the work had to be done step by step, and there was need of unusual precautions to prevent damaging the field or armature. Notwithstanding the difficulties involved, the machine was lowered safely to its foundation and in this position may be seen in Fig. 11.

In accordance with the standard practice of the company six exploring coils were placed in the slots between the coils, for the purpose of obtaining temperature measurements. The three hottest coils were located by test and connected to indicating instruments in the operating gallery, thus giving the attendants constant visual evidence of temperature conditions in the generator.

GIVING THE UNIT THE DRYING-OUT RUN

Before putting the unit in commission the usual drying-out run on short-circuit was made, 12.5 per cent. in excess of the normal full-load current being required to give the necessary heating effect. A heat run at 25,000 kw. showed a maximum temperature rise of only 33 deg. C. above the incoming air, and the temperature differential between incoming and outgoing air was 10 degrees.

The results obtained with the rebuilt generator and the successful accomplishment of this work reflect credit upon the designing engineers of the General Electric Co. and upon the engineers who carried out the work of handling and rebuilding.

The rebuilding of the armature was done under the supervision of A. F. Riggs, district engineer, and Charles M. Norman, superintendent of repair shops, for the General Electric Co. W. F. Sims, field engineer in charge of work at generating stations, supervised the work of handling the machine and was in general charge for the operating company.

Instructions for the Fireman

By ASA P. HYDE

The following rules are in substance those which have been prepared for the guidance of the firemen employed in the plant of which the author is chief engineer. Observance of these rules and suggestions will enable the fireman to save much coal that is wastefully burned.

THERE is a right time for covering furnace fires; determine it and fire, so far as possible, while the damper is closed. Cover only one side at a time, and that lightly, not so heavily that a bright fire cannot be seen through the new fuel. Do this as quickly and evenly and with as few scoopfuls as possible and do not overload the scoop. It is a knack to so handle the scoop that the coal will be evenly and easily scattered and cover the fire without bunching it and leaving it uneven. This requires practice, but it must be acquired. From four to six scoopfuls is enough to cover one side. Do not putter by throwing several half-scoopfuls in, thus keeping the furnace doors open an unnecessary time. Size up the fire quickly, then the quicker and neater the firing is done the more satisfactory the work and the results will be. The inrush of cold air through an open door at firing or cleaning times is ruinous to the entire apparatus, besides lowering the percentage of CO_2. This, by proper managing, can be largely avoided, and it must be done.

Except under extreme conditions always have the ashpit doors open; this preserves the grates and pits. It is well to carry some water in the pit, but not enough to make a nuisance in the ashes.

Keep the fires back to the inner edge of the deadplate and allow no fire or coal to accumulate on it under any circumstances. This must be observed as it saves the plates, doors, brick, fronts, etc. Furthermore, coal lying there is simply wasted. Keep the floor clean at all times, and allow no coal to stand either in front of the arches or on the floor of the bin, to be tracked in on the floor. This will serve to lessen the work of cleaning up in the plant. All firing is to be done from the coal car.

Burning Fires Low or Out

Do not allow the fire to burn out or too low or holes to form in it. By so doing more fuel will be consumed, as such conditions allow an inrush of cold air through the dead or low spots into the furnace, resulting in more ash, which causes clinkers, and a lowering of the CO_2; it is bad practice generally. Study the conditions and cover when the fire is ready, generally when it is near or at a white heat, at which time a fine white ash begins to rise; that is usually the proper time, but not always, so watch out. Never do this in a hit-and-miss fashion that may suit the convenience. The fires and the results are the first condition. Results cannot be obtained in any other way, and results are what we must have.

Raking, digging and fussing with a fire are generally unnecessary and must not be done except in extremes. Neglect will largely cause the extremes and they must be accounted for. Raking and then covering will not be allowed. There is no excuse for it.

Leveling is practically the same as raking. Keep the fires level by handling the shovel properly. You can do it. The leveling bar and rake are a lazy man's tools, and he simply does with them what he is too slack or incompetent to do otherwise.

Shaking and Cutting Fires

There can be no fixed rule for shaking and cutting fires, but it should be done only when actually necessary, and this does not mean to make up for neglect. Shake or cut down when judgment shows it is best to do so, but if the fires are properly handled it is not best except at cleaning time. With a heavy fire caused by hard running or poor fuel, it is best and proper. Letting a fire die down and then heavily covering it with fuel will make it necessary to shake and cut the fire, but this must not be done.

Carry as thin a fire as practice indicates is best, taking into consideration the fuel, both as to its quality and the quantity used. The percentage of CO_2 obtained will be a good indication, also the load and weather conditions, which will influence the draft and the length of time the damper will remain open. The heavier the fire the longer the damper will remain open and the more ashes will be made. A heavy load will usually require a correspondingly heavy fire. Too light a fire will permit excess air to enter the furnace; too heavy a fire will prevent enough air from reaching the fire. Study the conditions first and fire accordingly. A fire requires study and thought as well as fuel. Give it both.

Cleaning the Fires

Do not raise the steam pressure because you expect to drop it again or cannot hold it. It is bad practice and it is no credit to a fireman, and as the steam chart shows all of this, it is either a credit or a black mark. To clean, burn the fire down; this of course depends on the fire and other conditions. Do not load up the furnace first with a large quantity of fresh fuel to be handled all over and wasted while cleaning. Burn the fire down close, coal lightly and as soon as it is well ignited, cut as experience dictates.

This is generally done by pushing the grate lever back as far as it will go; then rock it ahead to or near the central position and then back again, doing this once or twice, depending on the condition of the fire. This will help to break up the fire and clinkers if there are any. Then pull the lever to the front or to the cutting position and push it back to the center position for dropping the ashes into the pit. Repeat the latter operation if necessary. Do all this quickly with the furnace doors closed and the damper blocked slightly open to carry off the dust. Do not cut too close, as the fresh fire will come down on the grates, which is ruinous as well as wasteful. Level the fires quickly with the hoe or rake, but it is not best to be too particular at this time. Cover very lightly all over with fresh coal and close the doors as quickly as possible. Then when the fire has burned up and the damper is again closed, level with the leveling bar or rake as needed.

In all cases avoid fussing or digging at the fire. Be quick. It is not the mark of a good or profitable fireman to be always at work at the fires or to have the hoe and poker red hot and burned up halfway to the handles. The one who sees and works quickly and then lets his fire alone to do its part is the successful fireman.

Be continually on the watch. Study your work and the results obtained. It will vary and what will do today may not work at all tomorrow. Avoid continually opening your doors to look in. If you watch the conditions, you should know what is taking place inside without having to continually look in. Do not be bothered by anyone when the fires or apparatus need your attention; to do so will cost us money.

Generally, the wastes in or around the boilers are equal to or more than all other plant losses combined. In our case help to cut them out.

THE DAMPER REGULATOR

So manage the fires as to keep the damper closed as much as possible. It was not put on to see how many times it will open and close. Help it out by doing your part. It alone cannot do the work. Use your head, and the regulator will make your work less. In connection with the main damper and regulator, use the hand uptake damper on each boiler, depending, of course, on conditions as to how much—but use it. Hold the heat in the arches, so that the boiler may absorb it. The combination of yourself, damper, water level and fire produces the steam chart and the results we want.

Wet the ashes in the pit just enough to hold the dust, but not enough to be sloppy. Take them up as soon after cleaning as possible. Fill the cans full, but do not pound the ashes in or overload. What you may save in this way will be taken out of the cans in handling, and they cost money. Be fair in loading them evenly so as to get as even an ash percentage as possible.

Always have a regular and continuous feed, not on and off, which produces poor results. Carry about four inches of water in the glass and keep it in there—not by continually changing of the water valve, but by so graduating it that it will carry at a fixed point. A steady feed is economy.

Remember that your boilers, if neglected, are as deadly as dynamite to you and to the building. Blow the water columns and glass regularly and know they are all right. Watch the entire apparatus—boilers, walls, arches, grates, steam and water lines, etc.—and report if anything is needed or irregular.

Carry the steam pressure steady. Uniform pressures are economy. Variations are expensive as to fuel and ruinous to the apparatus. The continual expansion and contraction on the apparatus both in the plant and in the building will in the end cause trouble. Positively, it must be avoided.

Providing the best and cheapest fuel for the plant requires your coöperation, both in the use of the fuel and in carefully and understandingly handling and checking it up. Let all work together.

PREVENTING SMOKE AND GASES

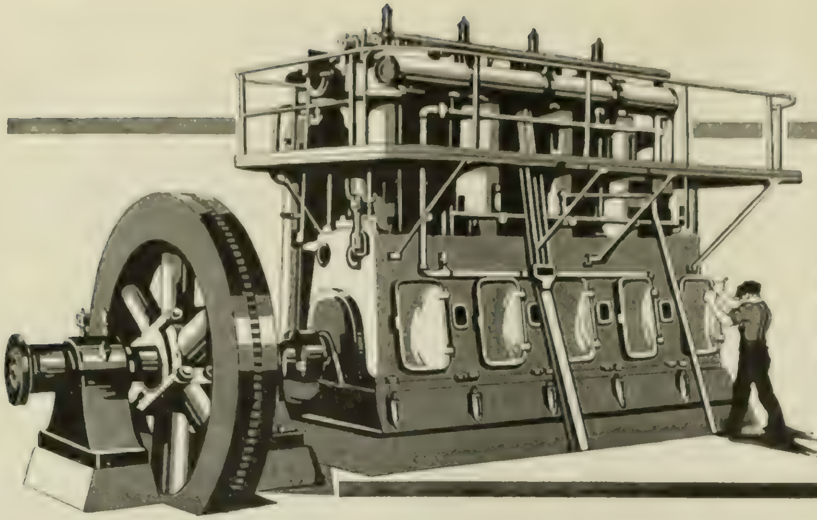
Smoke and gases can be largely if not almost entirely prevented by using good judgment in handling the fires. Fire only when a fire is ready and conditions tell you it is the time—one side only at a time, so far as possible, always lightly, when the damper is closed if possible and not just as it is about to open. In this way the gases from the fresh fuel will be ignited by the live fire and burned in the combustion chamber. The boiler will absorb the heat, and no gases (CO) will escape unconsumed.

No one can tell you all the kinks that go to make successful firing possible. You must study, read and watch for results. Note carefully what results each change or method produces. Different boilers, different conditions and especially different fuels, require different handling. Carefully study them and determine what is best. Have a system, then follow it.

GENERAL ATTENTION

The management has a right to expect the men in charge of the boilers or plant to be careful, conscientious and saving in all ways, both in labor and materials, to give the entire apparatus their careful and strict attention, live up to the rules, and to work for the interests of the men who employ them. Read books and papers in the engineering line. Firing, as well as running, is a trade, and it is so considered by the best engineers.

Do not be content to be a mere "coal shoveler." Be a fireman on your way up to a better position. Make room for yourself at the top. It is up to you. Then your services will be in demand. The company will do the best it can by you and treat you like men. In turn do your best by them and do not expect to stay and give them 95 cents' worth of work or knowledge for a dollar, any more than you accept it as your pay. With our combined efforts we can make our plant profitable and a credit to all. I know that you will help to do it.



Talks on DIESEL Engines

by L. H. Morrison

III—Egan goes into the details of rebabbitting worn-out bearings, advises against peening the metal, but urges that the bearings be scraped to fit the shaft snugly, unless the condition of the shaft makes this a waste of time.

AT THE next session of the Deisel-engine study class Kelly was the target for a broadside of inquiries as to how he was making out with the erection of the second-hand engine.

"Well," said he, "I got the frame onto the foundation and grouted in dead easy; but when I started to put the cylinders on the frame I sure ran smack up against a hard one. They had a pair of half-ton duplex hoists, and I was afraid that a cylinder would be too much for one. So I fastened a chain around two of the studs and hooked the two hoists to the ends. It was a tough job to get the men to pull alike so that the load would be the same on each hoist, but we did it and saved them from having to buy a larger hoist."

He turned to Egan, who had been a silent listener to his story.

"One thing does bother me, J. R.," he said, "and that is, the main bearings. I haven't lined up the engine or put in the bearings, but I unpacked them. Two of the middle ones are in bad shape. It looks like I'll have to run them over. The worst thing, though, is that the bearings are shorter than the distance between the crank throws. I can't see how I can fix that without running all the boxes again. If I don't, there is going to be a lot of side play."

"Well, Kelly, the running of a new bearing oughtn't to be hard for you. I'd suggest, however, that in making the new bearings, you change them from the style now on the engine. You understand that on a vertical engine the pressure is always downward. The upper half of the bearing has practically no pressure on it and so it needs only a small surface in contact with the shaft. Some builders make the upper half along the lines of this sketch (Fig. 1). You will note that the babbitt metal is placed at the ends only, resulting in a saving of some twenty dollars per bearing.

"In running a new bearing, get a large ladle (if you can't find a large one, get a cast-iron kettle), place the cast-iron bearing in the ladle over a hot forge and melt out the old babbitt. After the cast iron has cooled, clean it thoroughly and tin it. The idea of the tinning is to make a good bond between the babbitt and the cast iron. Many a bearing is ruined because of the neglect to do this. Then get a steel plate or a heavy smooth timber, lay a sheet of asbestos on top of this timber, set the bearing on end, as I have shown in Fig. 2, and seal the lower edge with moist fireclay. Next get a piece of pipe from the scrap pile. In this case the shaft is 9 in. in diameter, so a short length of 8-in. pipe will do fine. After centering this in the box, you are ready to run the bearing. If you decide to save some babbitt on the upper half, all you need do is to fill in the box with fireclay, leaving the ends clear."

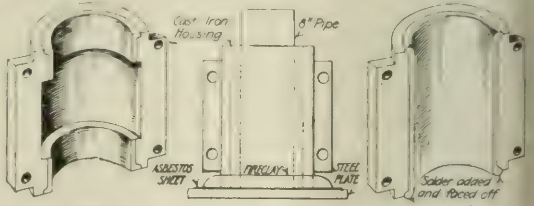


FIG. 1 FIG. 2 FIG. 3

FIGS. 1 TO 3. METHODS OF BABBITTING BEARING CAPS

"What about heating the bearing before running the babbitt?" Kelly asked.

"If you want to make a real bearing, you certainly want to heat the cast-iron housing before you run in the babbitt. If you get it good and hot, it will hold enough heat to let you set it on the asbestos sheet and center the pipe. Heating helps the babbitt to get a better grip. As you have noticed

Next week Egan will describe various types of connecting-rods and the methods used in adjusting them. He will also explain to the class how piston pins should be ground and lapped.

on our jobs here, the babbitted box is next bolted to the carriage of the lathe and bored out with a boring bar. A serviceable one can be made of 1½-in. cold-rolled shafting with a single-ended tool held in a slot by a setscrew. It is easy to level the box on the carriage so that the bore will be true.

"Another important detail," continued Egan, "is the radius or chamfer at the ends. I always feel that this chamfer can best be made with a scraping tool. Make it uniform around the bearing and get the radius big enough so that the fillet will not scrape on the crank throw. Notice that I've made no mention of peening the babbitt. I have noticed that many peened bearings show a tendency to leave the cast iron and the surfaces show fine cracks. The hammer evidently compresses the surface and causes the hardened or compressed portion to expand at a rate different from that of the babbitt nearer the cast iron. Even though engine manufacturers are practically unanimous in this peening practice, you'd better avoid it."

"I've examined the shaft and I don't believe it will pay to scrape the new bearing to fit the shaft," Kelly broke in.

"I dropped by the refinery at noon today," said Egan. "That shaft is so worn you'd never get results by scraping. But I believe that every bearing should be scraped to a nice fit, if the shaft condition doesn't make this impossible. In my opinion it's a poor engineer who will not take this trouble when there is so much invested in the Diesel engine.

"Now, as to the end play, since the faces of the bearings are worn, I'd suggest you clean all the bearings thoroughly. Get some muriatic acid and swab the entire box, tin the faces and run a thick ridge of good solder on the faces, covering the cast iron, as in Fig. 3. Take the bearing to the lathe, bolt the halves together, and true up the faces. Be sure to leave enough solder so that the clearance between crank throw and bearing face is correct."

"You have me there, chief," confessed Kelly. "What is the correct clearance?"

"That depends on the make of engine. In the one you are erecting, since it is pretty well worn, a clearance between the crank and bearing of fifteen-thousandths on each side would not be too much. But bear in mind that it is only necessary to correct the clearance on one bearing. One is enough to take up all side thrust. If it were new, I would think that five-thousandths clearance on each side would be about right. If it were a four-cylinder engine, such as the one we have here with the A frame, you could allow 7½-thousandths and still be safe. On the other hand, I notice that on some two-cylinder horizontal engines the clearance is around a hundredth of an inch. One erector who was here claimed that all the clearance necessary was a running contact, say two-thousandths; but I'd not care to work so close, for I hate to repair bearings."

Again Kelly interrupted. "What I don't see is why there is side play at all. It looks to me as if the connecting-rods can't move sideways and so the shaft must stay in one place."

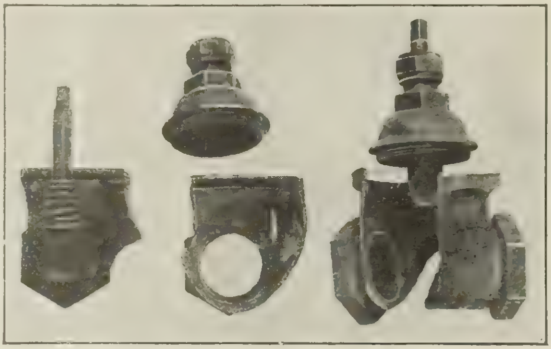
"That sounds all right," admitted the chief, "and I can't tell you why there should be side play. But I do know that I've never seen a direct-connected generating set of this kind that didn't have a sideways motion. I always thought that the harmonic-wave form of the current and its inductive effect on the rotor produced the side-to-side movement, but I wouldn't want to say that that's the right explanation."

A reminiscent look suddenly flooded his gray eyes. He arose, threw away the stub of his cigar and concluded the session by saying:

"I remember a case where we had a generating set that developed this side play, and one of the electricians suggested we move the stator frame sideways an inch, so as to bring all the thrust or pull on one side of the bearing. It worked all right; in fact, it worked too well, and as a result I had a bearing face to build up. The best plan is to allow some play."

Gate Valve Exploded

The illustration shows a 2½-in. gate valve that exploded while two workmen were attempting to remove a close nipple from one end. The valve had been stored in the warehouse, for nearly a year. In order to remove the nipple without damaging the valve the mechanic and his helper put the valve in a portable forge fire and proceeded to heat it, the mechanic holding the valve by the end of the stem with a pair of tongs while the helper turned the blower. Without any warning the valve exploded, the two pieces of the body and one disk going in opposite directions to the right and to the left and away from the workmen, one part carrying away the hood of the forge. The bonnet and stem blew toward the workmen, striking the helper on the arm, and a sliver of brass entered his eye, causing the loss of the sight. The explosion also turned the forge over.



PIECES OF EXPLODED VALVE

The valve was tightly closed and the pressure built up within the body was prevented from escaping by the two disks and the stem packing. It is not known whether there was any moisture trapped in the body of the valve before heating.

Considerable has been said recently about fabricated ships, and perhaps with not a very clear idea as to the meaning of the term. A fabricated ship is one on which the work of punching and shaping the plates and shapes, and to some extent assembling and riveting, is done at the works before they are forwarded to the shipyards.

Heating Versus Power Boiler Rating

By P. J. DOUGHERTY
Chief Engineer, International Heater Company

The object of this article is to show that the rules in general use for determining and comparing the rating or capacity of high-pressure boilers are not applicable to low-pressure or so-called heating boilers, and why. Almost all conditions of design and operation are different.

FEW high-pressure engineers concern themselves with the rules by which they can compare the capacities of different types of heating boilers. Heating engineers had no reliable rule until recently, when the American Society of Heating and Ventilating Engineers established its Heating Boiler Code. While the same principles apply to both heating and power boilers, their design and the conditions under which they operate differ radically, hence their requirements as to capacity and operation vary greatly. Fundamentally, each type consists of a furnace and a boiler proper; the furnace generates heat from the fuel, and the boiler generates steam from the heat and water. The importance of a dome or a space in which the steam and water are separated is often overlooked in heating-boiler design, and some cast-iron boilers require an expensive pipe header to do this separating. Modern cast-iron and power boilers separate the steam from the water within the boiler itself irrespective of the number and size of the flow outlets or whether the velocity of the steam is high or low, provided there is no extreme and sudden drop in pressure.

A HEATING BOILER'S CAPACITY CANNOT BE DETERMINED ON A GRATE-AREA BASIS

Unless the engineer realizes wherein the requirements of a heating boiler differ so radically from those of a power boiler, he will frequently do a great injustice to his friends who seek his advice as to the best boiler to buy. It is a simple matter to determine the capacity of a power boiler. According to Kent, "It is a general practice among builders to furnish from 10 to 12 sq.ft. of heating surface per horsepower, and not less than ⅓ sq.ft. of grate surface should ordinarily be furnished per horsepower." A rated boiler-horsepower is considered equivalent to 138 sq.ft. of direct steam radiation, but no such rule can be applied to heating boilers because there is no such uniformity in "general practice among builders" of heating boilers. In fact, there is such a wide difference in the numbers of square feet of heating and grate surface per hundred feet of radiator capacity among the leading makes of heating boilers that in comparing their relative capacities one may as well compare the relative areas of their fire-doors or smoke-pipes as their relative grate areas or heating surface, as will be seen by Table I, of grate areas, compiled from the current literature and catalogs of prominent heating-boiler manufacturers. It proves that it is a waste of time and effort to attempt to determine a heating boiler's capacity on a grate-area basis, and the following list might be extended indefinitely. The sizes fall into three groups, averaging practically 5, 10 and 18 sq.ft. respectively. In the first group there is less than one square foot difference of grate areas between the 900-ft. and the 2000-ft. boilers. In the second group the 4800-ft. boiler has a smaller grate than the one rated at 2275 sq.ft. In the third group the 800-ft. boiler has a smaller grate area than the 4200-ft. boiler, nearly all of the boilers being widely known and in general use.

TABLE I GRATE AREA VERSUS CAPACITY

Grate, Sq.Ft.	Rating, Sq.Ft.	Grate, Sq.Ft.	Rating, Sq.Ft.	Grate, Sq.Ft.	Rating, Sq.Ft.
4 90	1,100	9 36	1,950	17 50	6,000
4 90	1,200	9 50	3,600	17 50	7,350
4 90	1,400	10 00	2,900	18 00	5,275
4 98	900	10 00	3,250	18 00	5,300
5 63	1,200	10 00	4,800	18 00	5,400
5 63	1,400	10 50	2,800	18 00	5,850
5 63	1,500	10 50	3,250	18 00	6,300
5 63	1,650	10 50	3,500	18 00	6,800
5 83	2,000	10 50	3,600	18 00	8,000
5 84	1,575	10 92	2,275	18 24	4,200

Lack of definite relation between grate area and rated capacity does not necessarily indicate improper ratings. It merely proves that the grate-area rule borrowed from power practice never had and never will have any practical value or application to low-pressure boilers, as a study of the table shows. The grate-area rule does not even apply to all boilers made by the same company, much less to those made by different companies. Many magazine articles and books on heating and ventilation contain elaborately worked-out rules and equations to determine a heating boiler's capacity by its grate area. Such rules are not only worthless but misleading, since they are based on wrong principles and cannot be made right. The new Heating Boiler Code has superseded all such rules.

ONLY ACTUAL TESTS WILL DETERMINE THE RELATIVE MERITS OF DIFFERENT HEATING BOILERS

Books and articles also contain elaborate rules and equations for the amount of heating surface boilers should contain. Such rules are generally based on power practice that a square foot of heating surface develops about three pounds of steam per hour. It is anything but scientific to attempt to establish a rule or law on such flimsy premises as assumption and analogy, which have been the only foundation for these rules when applied to heating boilers. Because the factors and conditions operating in each case vary so widely, what a square foot of heating surface in a B. & W. or a Scotch marine does is no criterion as to what a square foot of heating surface in heating boilers may do, and what a square foot of heating surface does in one heating boiler is no criterion as to what a square foot of heating surface will do in another one if designed along radically different lines. The only way to determine the relative merits of any two heating boilers, irrespective of their relative grate or heating-surface areas, is by actual tests, according to the boiler code of the A. S. H. and V. E. conducted by a competent and impartial research bureau such as it is hoped this society will succeed in establishing. Until such a time the public must depend upon the capacities given by the manufacturers, which in some cases are reliable and in accord with the new boiler code.

It may be a surprise to many who have had no practical experience in designing heating boilers to learn that the amount of heating surface in a modern cast-iron boiler is of such secondary importance that the engineer who designs it sometimes does not even know its area. It is the design or rather location of the heating surface and not so much the amount of the heating surface that produces efficiency. The engineer who designs a cast-iron boiler can mold or place the heating surface where it will be the most effective as freely as an artist molds his clay in producing his masterpiece. Not so, however, with the designer of steel boilers. He is so cribbed and confined in the use of shapes because of pressure conditions that he has little or no chance to assert his individuality or make practical application of the latest results of experimental research. Hence very little improvement has been made in the efficiency or capacity of a square foot of heating surface in power boilers during the last century. The progress made along those lines in cast-iron boiler design is so rapid that some of the modern boilers show a higher efficiency and capacity with only one-half to one-fourth of the amount of heating surface of those designed ten to twenty or more years ago.

HEATING SURFACE AND RATED EVAPORATION CAPACITY

The evaporation capacity in relation to heating surface in power boilers averages about three pounds of steam per hour, which is far below that of a modern cast-iron boiler. It is evident that too much of the heating surface in a power boiler lies too near the zero end of the scale and very little up toward the 100 per cent. end, while almost any heating boiler is required to develop its rated capacity while evaporating about nine or ten pounds of water per square foot of heating surface. Fifty square feet of heating surface in a boiler averaging eight pounds of steam per hour is far superior to two hundred square feet averaging two pounds of steam per hour, there being so much less chance for soot pockets, high draft resistance, short-circuits, less metal to heat up, etc. The excess iron placed in the heating surface of a boiler because of faulty design is so much junk sold at finished-product prices. The less heating surface required to produce the required results the more efficient the design.

The power-boiler heating-surface rule grafted on low-pressure boiler practice has even less practical value in determining a heating boiler's capacity than the grate-area rule, as an examination of Table II will convince the most skeptical. Like the grate-area table, this heating-surface table is compiled from the current literature and catalogs of some of the most prominent heating-boiler manufacturers and the number might be greatly extended.

TABLE II. HEATING SURFACE VERSUS RATED CAPACITY

Heating Surface, Sq.Ft.	Rated Capacity, Sq.Ft.	Heating Surface, Sq.Ft.	Rated Capacity, Sq.Ft.	Heating Surface, Sq.Ft.	Rated Capacity, Sq.Ft.
83	900	116	900	223	5,375
89	1,625	117	2,400	224	1,700
91	1,125	122	1,575	330	4,400
98	700	177	2,300	340	8,350
107	2,100	185	3 675	340	4,550
114	1,400	190	1,400	344	3,000

Notice that the 1700-ft. boiler has nearly three times as much heating surface as the 1625-ft. boiler; the 3000-ft. boiler has more heating surface than the 8350-ft. boiler; the 4550-ft. boiler has the same amount of heating surface as the one for 8350 sq.ft., although both are made by the same company but of different design.

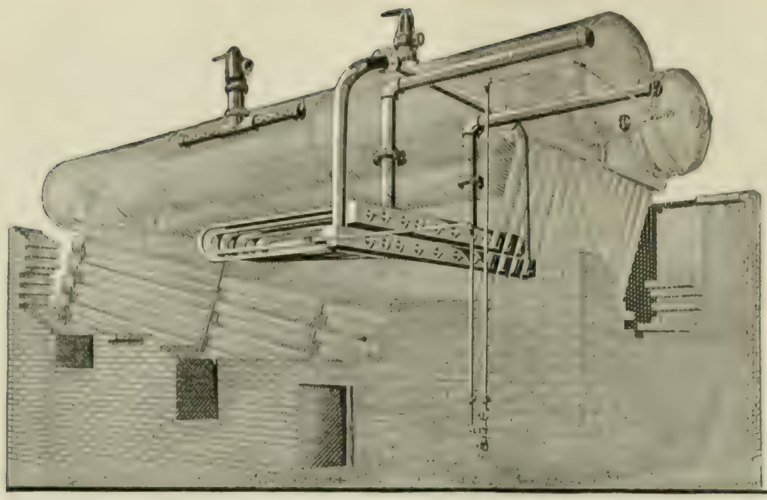
The reason high-pressure boiler rules have no application whatever to low-pressure practice is due not only to the difference in design, but also to conditions of operation, such as length of firing period, kind of fuel used and different draft conditions. In the A. S. H. and V. E. Boiler Code the available fuel, the evaporative power and the length of firing period are factors considered. With hard coal not less than 20 per cent. of the boiler's coal capacity is for continuing the fire, the remainder being considered as available, as per code test. Because of the great difference in the nature and quality of soft coals no such percentage basis can be applied. The coal capacity may be determined by actual measurement. The evaporative power or efficiency, however, can be determined only by actual test according to the boiler code. The available fuel times the evaporative power gives the total boiler capacity in pounds of steam.

LENGTH OF FIRING PERIOD IMPORTANT FACTOR IN HOUSE HEATING

The length of the firing period, while a negligible factor in power practice, is the most important factor in house heating. The total capacity divided by the length of firing period gives the hourly rated capacity. House-heating practice demands an 8- to 12-hour firing period with hard coal. Large boilers for apartments and public buildings are usually rated on a 4- to 6-hour period with hard coal. Soft-coal boilers are rated on an hourly basis because of the nature of soft coal. The available fuel in pounds times the evaporative power in pounds divided by the length of the firing period in hours gives the hourly rated capacity in pounds of steam. The hourly capacity in pounds of steam times 4 gives the rated capacity in square feet of direct steam radiation, since four square feet of direct steam radiation condenses one pound of steam per hour.

The A. S. H. and V. E. in establishing the foregoing excellent rule complied with the golden rule in doing unto the manufacturer as they expect their clients to do unto them. They tell the manufacturer what results they expect from his boilers, but refrain from telling how he should design his boiler in order to produce those results, the number of square feet of grate or heating surface, etc. They, as engineers, likewise look to their clients to tell them what results they expect to get, but insist that the owner keep "hands off" as to how the heating or ventilating system shall be designed in order to produce those results.

It is not beyond the bounds of reason to foresee a condition whereby a householder, in the place of the ton of anthracite that he now welcomes for $11, will receive a ton of smokeless coal without slate, a month's supply of cooking gas, 40 miles of motor fuel, enough fertilizer to start a small garden, and tar sufficient to lay the dust in front of his house—all for far less money than he now pays for inferior coal.



DETERMINATION OF SUPERHEATER SURFACE

by
C. H. Baker*

The author gives charts showing the relationship between superheat and the factors that influence it. One of the charts enables the engineer to determine the square feet of superheating surface when the superheater location and degrees superheat are known, or to obtain the degrees superheat when the location and surface are given; or if the surface and superheat are specified, to determine the location. This chart is of size suitable for use in an engineer's loose-leaf data book.

THE present tendency for higher steam pressures forces the superheater into greater prominence, since the degree of superheat must be increased proportionately with the pressure to insure the same degree of dryness of the steam in the turbine as with the lower pressures. Present turbine design will not admit of higher temperatures than 650 deg. F. to 700 deg. F., and maximum power-station economy must be realized with these figures as a limit. Therefore, when the pressure is fixed, the degree of superheat is confined to comparatively narrow limits. Superheaters designed by the rule of thumb occasionally meet their guarantees, but experience has shown that they usually fall below, which may be due to one of many reasons, but since superheaters are usually sold on horsepower instead of a square-foot basis, the usual reason is lack of surface. The simplest and obviously cheapest remedies are to improve the heat transfer in the given surface by readjusting the boiler or superheater baffles, thus increasing the velocity or temperature of the gas, as the case may be, at the superheater, with a consequent reduction in capacity or over-all efficiency; or increase the steam velocity by inserting cores in the superheater tubes, which give an increased pressure drop through the superheater and a decrease in the life of the tube. The pressure drop through the superheater also has the effect of cutting down the turbine capacity unless the turbine is designed to carry full load at the reduced pressure. It seems a waste of money to purchase a high-pressure boiler when the pressure cannot be utilized at the turbine on account of the pressure drop through the superheater and piping.

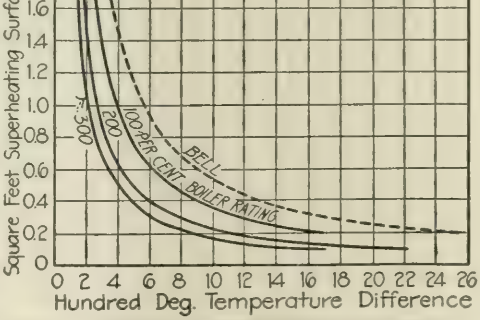


FIG. 1. RESULTS WITH VARIOUS FORMULAS COMPARED WITH BELL'S

Although superheaters have been manufactured for fully sixty years, available data and literature for purposes of design are meager. Several empirical formulas appeared in both the American and foreign press some ten years ago, of which J. E. Bell's formula in the Transactions A.S.M.E., 29-267, 1907, is typical of all forms and is as follows:

$$S = \frac{10t_s}{2(T - t) - t_s}$$

where

S = Square feet of superheating surface per boiler horsepower;

t_s = Superheat, deg. F.;

T = Temperature of gas entering the superheater, deg. F.;

t = Temperature of dry and saturated steam at boiler pressure, deg. F.

The required superheating surface is governed by the required superheat, the temperature of the entering gas and steam, the velocity of the gas and steam through the superheater, the quality and quantity of the entering steam and the conductivity and cleanliness of the superheater material.

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If there is no heat lost to radiation, the heat balance for the heat taken up by the steam may be expressed:

$$SUt_m = WCt_s \qquad (1)$$

where

S = Square feet of superheating surface per boiler horsepower;

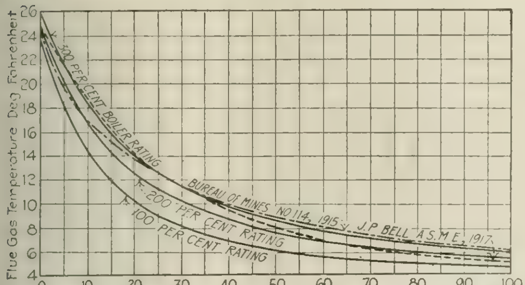


FIG. 2. RELATIONSHIP OF BELL'S AND BUREAU OF MINES FORMULA

U = Heat transfer per square foot per hour per degree mean temperature difference, B.t.u.;

t_m = Mean temperature difference between the gas and steam, deg. F.;

W = Pounds of steam per boiler horsepower passing through the superheater;

C = Mean specific heat of the superheated steam, B.t.u.;

t_s = Superheat, deg. F.;

T = Temperature of gas entering superheater, deg. F.;

t = Temperature of saturated steam at boiler pressure, deg. F.

If T is assumed to be the average temperature of the gas at the superheater and $t + \frac{t_s}{2}$ the average temperature of the steam in the superheater, the arithmetical mean temperature difference, which is sufficiently accurate, may be expressed as follows:

$$t_m = T - \left(t + \frac{t_s}{2}\right)$$

substituting this value of t_m in equation (1) and transposing,

$$S = \frac{2WC}{U} \times \frac{t_s}{2(T - t) - t_s}$$

Bell assumed the value of $W = 30$, $C = 0.5$, and $U = 3$, which values were sufficiently accurate in the early days of low boiler-forcing rates and low steam pressures.

Bell also gives a formula of the logarithmic form for determining the value of the unknown quantity $(T - t)$ where the superheater is to be designed for a new boiler, as follows:

$$\frac{1}{(T - t)0.16} = 0.172H + 0.294$$

Comparison of tests on a modern horizontal water-tube boiler with these formulas, with the superheater located at the top of the first pass, are given below.

Boiler Data:

1375 hp. boiler, 12-foot setting.
1711 sq.ft. superheating surface.
16-retort underfeed stoker.
62 ratio heating to grate surface.

Test Data:

220 lb. = average boiler pressure during test.
$t = 369$ deg. F. average temperature steam entering superheater.
$t_s = 95$ deg. F.; $T = 700$ deg. F. at 100 per cent. rating.
$t_s = 124$ deg. F.; $T = 890$ deg. F. at 200 per cent. rating.
$t_s = 140$ deg.; $T = 1030$ deg. F. at 300 per cent. rating.

Square feet of superheating surface per boiler horsepower generated:

$S = 1.25$ sq.ft. per b.hp. at 100 per cent. rating.
$S = 0.625$ sq.ft. per b.hp. at 200 per cent. rating.
$S = 0.417$ sq.ft. per b.hp. at 300 per cent. rating.

Let A represent the quantity $\frac{2WC}{U}$ that is contained in equation (2) or the value of 10 in Bell's formula for surface. Then A represents a quantity that varies with specific heat and weight of steam, heat transfer, and steam and gas velocities; all of which fluctuate with the rate of forcing.

Introducing the test values at the various forcing rates in the formula,

$$A = \frac{(2(T - t) - t_s)S}{t_s}$$

we have for the three forcing rates,

$A = 6.75$ at 100 per cent. rating,
$A = 4.35$ at 200 per cent. rating,
$A = 3.35$ at 300 per cent. rating,

and the revised formulas for superheating surface then become

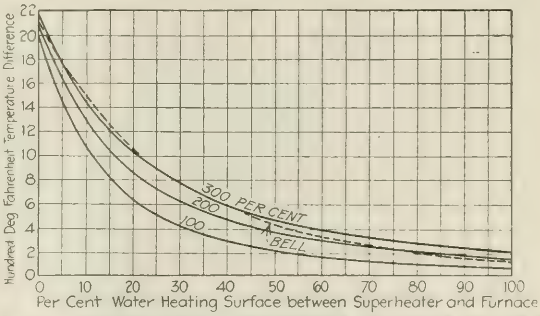


FIG. 3. TEMPERATURE DIFFERENCE OF STEAM AND GAS AGAINST PERCENTAGE OF HEATING SURFACE

$$S = \frac{6.75t_s}{2(T - t) - t_s} \text{ for 100 per cent. rating}$$

$$S = \frac{4.35t_s}{2(T - t) - t_s} \text{ for 200 per cent. rating}$$

$$S = \frac{3.35t_s}{2(T - t) - t_s} \text{ for 300 per cent. rating}$$

Fig. 1 shows the comparative results from these formulas with Bell's for 100 deg. F. superheat.

The flue-gas temperatures were taken in the furnace, at the top of the first pass or superheater entrance,

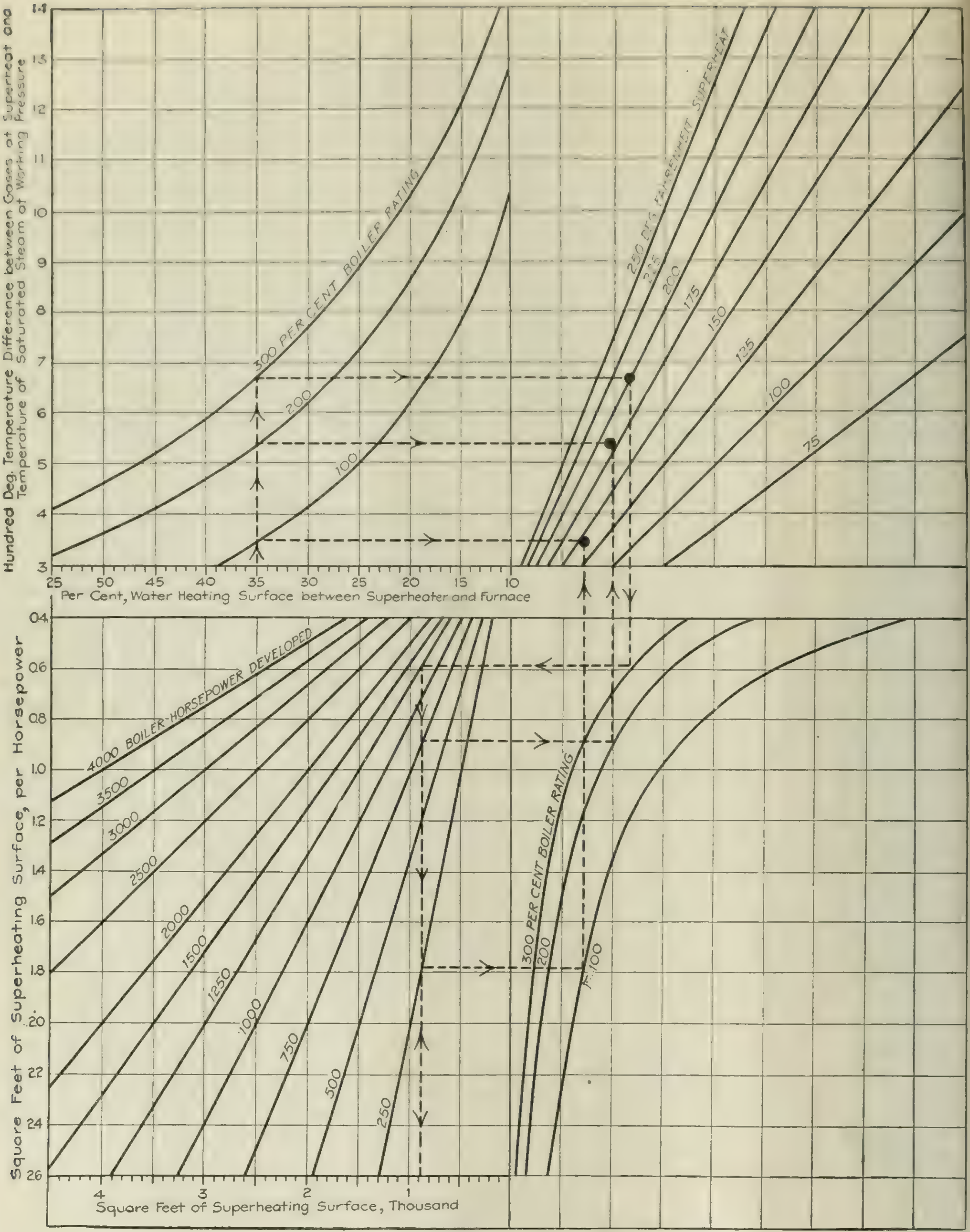


FIG. 4. CHART FOR DETERMINING THE REQUIRED SUPERHEATER SURFACE

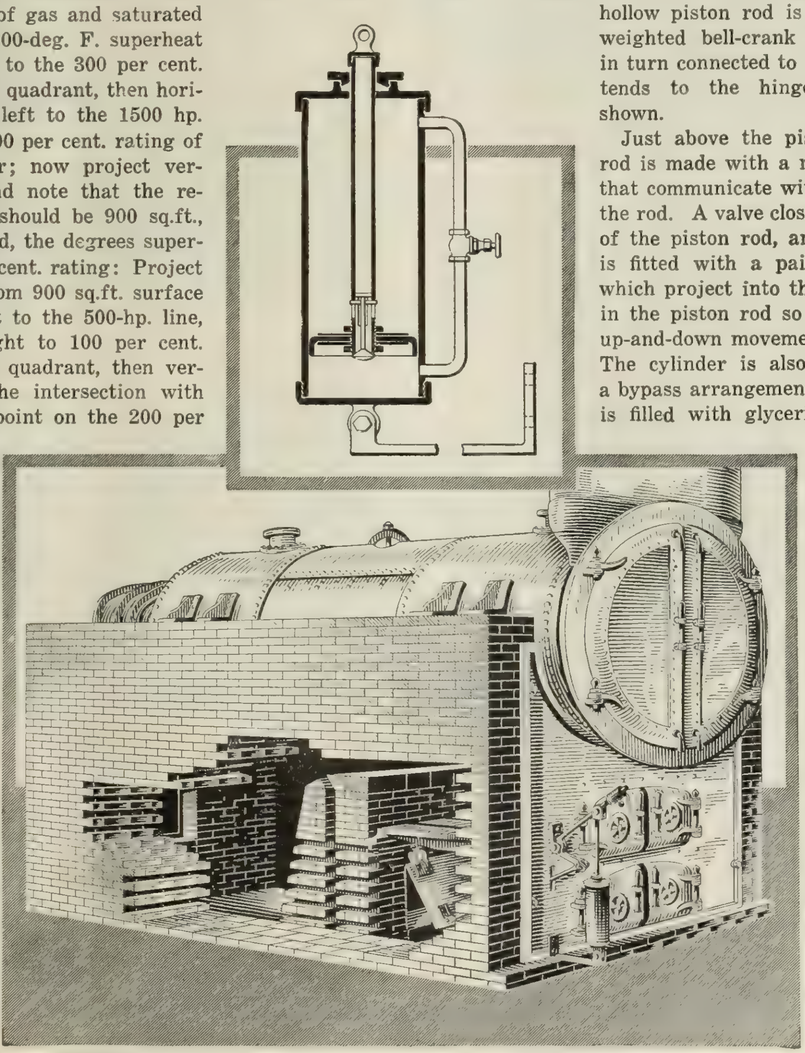
at the top of second pass or superheater exit, at the top of third pass and flue. The average values were plotted against heating surface for the various forcing rates and replotted against percentage of heating surface, as shown in Fig. 2, for comparison with Bell's and the Bureau of Mines values. The relationships of Bell's and the Bureau of Mines values with the 300 per cent. curve are almost identical around 30 to 40 per cent. heating surface traversed, which is the usual location for a superheater at the end of the first pass. The test curves were then replotted in Fig. 3, showing the temperature difference of gas and steam against percentage of water-heating surface and formulas derived for the various forcing rates.

GENERAL APPLICATION OF SUPERHEATER FORMULAS

Fig. 4 is a compilation of the test curves and is drawn up to facilitate the work of obtaining the square feet of superheating surface when the superheater location and degrees of superheat are given; or if location and surface are given, to obtain the degrees of superheat; or if surface and superheat are specified, to determine the location.

Problem: Given a 500-hp. water-tube boiler with a superheater to be located in the first pass. There is 35 per cent. water-heating surface in the first pass, and the superheater must generate steam at 200 deg. F. superheat at 300 per cent. rating. What should be the square feet of superheating surface and what would be the superheat at 100 per cent. and 200 per cent. rating?

Solution: In the upper left-hand quadrant read up from the 35 per cent. to the 300 per cent. curve, then to the right horizontally (noting 670 deg. temperature difference of gas and saturated steam) to the 200-deg. F. superheat line, then down to the 300 per cent. line in the third quadrant, then horizontally to the left to the 1500 hp. line, which is 300 per cent. rating of a 500-hp. boiler; now project vertically down and note that the required surface should be 900 sq.ft., nearly. Required, the degrees superheat at 100 per cent. rating: Project vertically up from 900 sq.ft. surface in the quadrant to the 500-hp. line, then to the right to 100 per cent. rating in third quadrant, then vertically up to the intersection with a line from a point on the 200 per cent. curve directly over 35 per cent. water-heating surface in first pass and note 145 deg. F. superheat. Similarly, to find the degrees of superheat for 200 per cent. rating read up from 900 sq.ft. in the fourth quadrant to 1000 hp., or 200 per cent. load, and note by following the line that it shows 180 deg. F., superheat.



DETAILS OF SMOKE PREVENTER AND APPLICATION TO FURNACE

Kosel Smoke Preventer

With the enactment of municipal smoke-nuisance laws attention was diverted to the perfecting of apparatus that would assist in the smokeless combustion of fuel. Many such devices have been invented, one of the latest being the Kosel smoke preventer, patented by Henry G. Kosel, of 405 East 168th St., New York City.

In this particular arrangement, shown in the illustration, the boiler setting is similar to the ordinary method employed, with the exception that the bridge-wall is supplemented by a second one built behind the usual bridge-wall, but so arranged that an air space is left between them. The opening at the top of the bridge-wall is such as to direct the escaping air toward the combustion chamber. Through this chamber the additional air necessary to carry on smokeless combustion is admitted to the furnace.

Control of the air passing through the bridge-wall is by means of a damper hinged on the front face of the bridge-wall, operated by a bell-crank lever and cylinder placed at the front of the boiler setting. This cylinder contains a leather piston, and the upper end of the hollow piston rod is connected to a weighted bell-crank lever which is in turn connected to the rod that extends to the hinged damper, as shown.

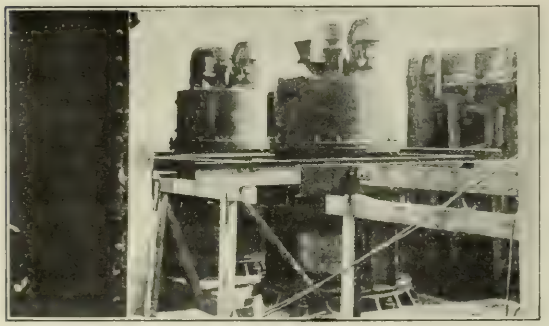
Just above the piston the piston rod is made with a number of ports that communicate with the hollow in the rod. A valve closes the lower end of the piston rod, and a valve stem is fitted with a pair of crossarms which project into the shortest slots in the piston rod so as to limit the up-and-down movement of the valve. The cylinder is also provided with a bypass arrangement. The cylinder is filled with glycerin or oil so as to retard the downward movement of the piston, thus acting as a check on the closing of the bridge-wall damper. The operation of the arrangement is as follows: At the time of adding fresh fuel to the furnace the fireman lifts the weighted lever, which permits the glycerin in the cylinder to flow through the port openings in the piston rod against the valve and into the lower part of the cylinder. This lifting of the lever also opens the damper in the bridge-wall, and air is thus admitted to the air space between the bridge-walls. As the weight of the lever forces the piston down, the resistance of the glycerin seats the valve, and the glycerin can escape to the upper side of the piston only through the bypass; and as this is fitted with a valve, the flow of glycerin to the top part of the cylinder can be adjusted so as to cause a longer or shorter time for closing the air damper. By this means the supply of air to the combustion chamber can be regulated so as to maintain smokeless combustion in accordance with the amount of fuel that is fired at one time.

Burning Powdered Coal Successfully

The additional equipment necessary consists of crushing and pulverizing mills, driers, inclosed storage bins together with conveyors and elevators.

AN EXPERIMENT in the burning of powdered coal was carried out recently by the Puget Sound Traction, Light and Power Co. For this test a 300-hp. water-tube boiler at the Western Avenue steam heating station in Seattle was equipped with a "dutch oven." The powdered coal was delivered to an inclosed bunker by bucket elevators. From the bunker the coal was fed by air pressure through pipes and a locally designed burner to the furnace.

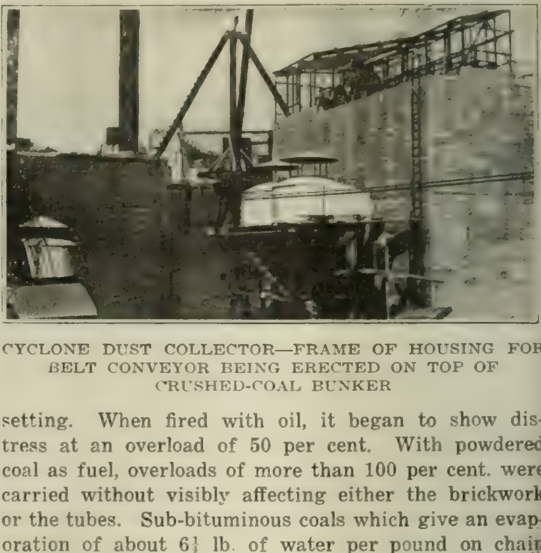
Various difficulties were experienced at first, one of the most annoying being the formation of slag on the boiler tubes. This was due to insufficiency in space between the burners and the tubes, with the result that combustion of the solid matter of the coal was not completed in the firebox, but was still going on among the tubes, the stream of burning coal being from 12 to 14 ft. long. Two means were found for correcting this evil, one by furnishing a longer path for the flame and the other by introducing steam into the fire. The effect of the latter was quite remarkable, resulting in a decrease in flame length of about 50 per cent., the amount of steam required being less than that used for atomization with an oil burner of good design.



TWO OF THE PULVERIZING MILLS UNDER ERECTION. STEPPED CONE PULLEYS ARE FOR SCREW FEED—DRIVE PULLEYS CAN BE SEEN AT BASE

With the shortened flame length, the fused portion of the ash is deposited on the furnace walls before reaching the tubes and flows down into the ashpit, leaving a glazed coating about $\frac{1}{16}$ in. thick on the brickwork. Some difficulty was experienced from accumulation of slag in the ashpit in a solid block which required the use of bars to break up. This difficulty was finally overcome by constructing the throat of the slag pit so that the molten slag was forced to drop from the furnace in semifluid masses, and by using a water spray which prevented successive droppings from sticking together. Under this treatment the slag accumulates in the pit in chunks about the size of a large potato and is easily removed with a rake through the usual clean-out door.

This boiler had previously been used with an oil setting. When fired with oil, it began to show distress at an overload of 50 per cent. With powdered coal as fuel, overloads of more than 100 per cent. were carried without visibly affecting either the brickwork or the tubes. Sub-bituminous coals which give an evaporation of about 6¼ lb. of water per pound on chain grates gave better than 8½ lb. evaporation per pound of pulverized product when burned in powdered form, corresponding to an increase of 20 to 25 per cent. in the evaporative performance of the raw coal.



CYCLONE DUST COLLECTOR—FRAME OF HOUSING FOR BELT CONVEYOR BEING ERECTED ON TOP OF CRUSHED-COAL BUNKER

Almost perfect control of the fire was possible by regulating the speed of the supply fan by means of a rheostat controlling a variable-speed motor. The boiler was equipped with an indicating steam-flow meter, and its responses to changes in fan speed were almost like those of an ammeter on an electric generator.

After three months of operation, during which time all obtainable grades of coal were burned, from high-grade bituminous to the poorest lignites, it was demonstrated conclusively that coal of the character obtainable in this region could be successfully burned in powdered form under steam boilers. It was shown also that the performance of all grades when burned in this way was superior to any other method of firing, the improvements in the case of the lower grades being relatively greater than for bituminous coal.

As a result of these experiments, it was decided to equip the entire Western Avenue plant for burning powdered coal. As the station was equipped for burning oil, it was necessary to provide coal and ash-handling equipment and storage facilities and to change the furnace design as well as to supply the equipment required for drying and pulverizing the coal.

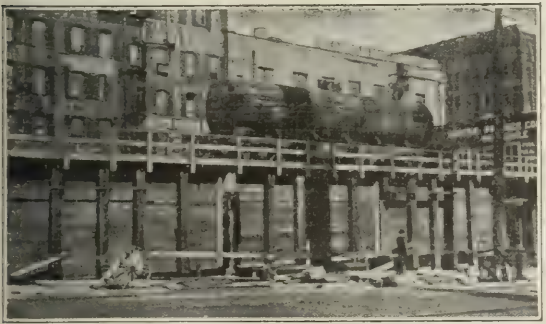
THE NEW BUILDING AND ITS EQUIPMENT

The pulverizing plant will be housed in a new concrete building adjacent to the station. Coal will be delivered from the bunkers and fed by gravity onto a rubber belt conveyor, which will carry it to a crusher of the single-roll type. This belt will deliver the coal to a vertical elevator of the two-strand chain and bucket type just inside the pulverizing plant. After being crushed the coal will be raised to the roof and distributed to the crushed-coal bunker by a flight conveyor.

The crushed-coal bunker will extend the width of the building and have a capacity of 300 tons. From two openings in the bottom of this bunker the coal will be fed by apron-type feeders to chutes communicating with the driers on the floor below. The spill from the apron feeders will be picked up by screw conveyors and delivered to the chutes, which are to be so arranged that coal can be fed from either end of the bunkers to either of the two driers.

The driers will consist of two steel cylinders, 55 ft. long, one 5 ft. and the other 6 ft. in diameter. They will be slightly inclined to the horizontal and arranged for rotation about the longitudinal axis. Steel baffles will be arranged longitudinally inside, which will successively raise the coal and drop it as the cylinder rotates, thus forcing the coal, because of the pitch, gradually to pass through the drier.

Heat for drying will be supplied by furnaces which will inclose the driers for the greater part of their length. The furnaces will be fired with powdered coal and the gases of combustion will pass into the driers at the discharge ends and be sucked through the shell, together with the moisture and dust from the coal, by fans at the opposite ends. These fans will discharge into cyclone dust collectors installed on the roof.



RAW COAL BUNKERS EXTEND BELOW STREET LEVEL WITH BELT CONVEYOR BENEATH THEM

After drying, the powdered coal will be delivered to the dry-coal bunker on the roof by means of a bucket elevator. From the dry-coal bunker the coal will feed through chutes to four pulverizing mills. These will grind the dry coal to a fineness permitting 95 per cent. to pass a 100-mesh screen and 85 per cent. to pass a 200-mesh screen. The powdered coal will be carried from these mills by screw conveyor to the north side of the building, raised to the roof by bucket elevators and distributed by screw conveyors to steel bins in the boiler plant.

The powdered coal will be taken from the bottom of the steel storage bins by short screw conveyors driven by variable-speed motors and delivered into down pipes communicating with the burners. The passage of the coal through the down pipes is facilitated by air.

Dutch ovens have been constructed in front of each boiler and the floor cut away to provide the necessary furnace volume and slag pits. The clean-out doors for the slag pits are at the basement floor level under the boiler room, and slag will be handled in wheelbarrows to a bucket elevator which will raise it to the top of a concrete ash bunker. This bunker is arranged to discharge into railroad cars or auto trucks.

DRIER BEFORE PLACING BRICKWORK, WITH DRIER FURNACE IN BACKGROUND

Further details of this installation are given in an article by G. E. Quinman in the July issue of the *Puget Sound Electric Journal.*

Government a Large Owner of Machine Tools

Last year under the stimulus of war demand the machine tool industry of the country reached a productive capacity of around $400,000,000 a year, equivalent at pre-war prices to $250,000,000. Of so-called standard lines, the annual output is placed at about $100,000,000 now, compared with $50,000,000 in 1914.

After cancellations of war contracts, about $300,000,000 worth of government-owned machine tools were turned over to the salvage committee of the War Department to be placed on the market again. Of this total approximately $200,000,000 worth are standard machine tools in new or prime condition.

As a means of disposing of this large stock of government-owned tools, it has been suggested that the machine-tool builders dispose of one government machine for each one sold from their current manufacturing stock. It will probably require about four years to clean up the government stock. It is possible that the surplus of machine tools will be used to rehabilitate the industries of Belgium and northern France. This particular subject will be investigated by Chairman Baruch of the War Industries Board and Director Replogle of the steel division while they are in Europe—*Boston News Bureau.*

The Electrical Study Course—Parallel Operation of Generators—II

Continues the discussion of the preceding lesson. Explains why shunt generators operate in parallel satisfactorily, and goes on to give the theory applying to the cutting-in and cutting-out of such machines.

In the preceding lesson it was shown that a study of the external characteristic curves of generators led to the conclusion that shunt generators would operate successfully in parallel and that compound ones would likewise do so, but that the conclusion in regard to the latter type was erroneous and that an extra connection, called the equalizer, had to be used to keep the loads upon them balanced. The reasons for the failure of the compound type to operate together satisfactorily without an equalizer were explained, and it was shown how the equalizer overcame the difficulty encountered.

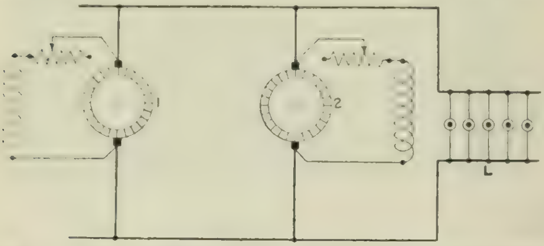


FIG. 1. TWO SHUNT-WOUND GENERATORS CONNECTED IN PARALLEL

The next subject to be investigated is why shunt generators exhibit no tendency to unbalance when connected in parallel. In reality the explanation was given in the course of the discussion on compound machines. It was found that their instability was due entirely to the influence of the series-field currents. When this was corrected by means of the equalizer, the generators worked without any hitch although no change whatever had been made in the manner of using the shunt fields, and consequently it is to be presumed that if the series fields were removed entirely, the machines would continue to run as shunt generators without any disturbance. To investigate the behavior of shunt generators in parallel, reference will be made to Fig. 1. Assume that the two generators Nos. 1 and 2 are delivering current to a load *L*, and that the load is equally divided between them. Suppose, now, that, due to some cause, such as a slight increase in speed, the generated voltage of generator No. 1 is augmented. The result will be to increase the current delivered by it since $I = \frac{E_g - E}{R}$, where I represents armature current, E_g generated voltage, E terminal voltage, and R armature resistance. However, an increase of current in a shunt generator tends to decrease the terminal voltage, which in turn would decrease the current. We therefore have the condition that the very increase of the current acts as a check upon itself to prevent any further growth, which is the exact reverse of what was found to be the case with compound generators.

Having found the effect upon generator No. 1, let us investigate what happens in No. 2 during the same period. Since the load upon the machines remains practically the same, the part supplied by No. 2 must decrease if anything occurs to increase that delivered by No. 1. A reduction of current in a shunt machine tends to increase its terminal voltage, which would cause an increase of current. Hence we have a condition just opposite to that found in machine No. 1: namely, that a decrease in current automatically operates to cause an increase and thereby prevents the cumulative action found in the case of compound machines. The net result of the actions in the two generators is an effort to make themselves continue to share any joint load upon them equally, once they have been adjusted for that condition, in opposition to any influence tending to unbalance the equal distribution. Of course it is understood that they must have identical external characteristic curves if they are to maintain the correct division of the load when it changes, as was explained in the previous lesson.

It is apparent from the foregoing that the satisfactory behavior of shunt generators in parallel is a result of the fact that the terminal voltage falls with increase of current and rises with decrease thereof, a condition indicated graphically by their external characteristic curves, of which *A* in Fig. 2 is a typical example. On the other hand, generators whose terminal voltage rises with increase of current—that is, overcompounded ones—refuse to operate in parallel without the use of an equalizing connection, as shown in the previous lesson. A typical example of the external characteristic of such machines is *B* of Fig. 2. The

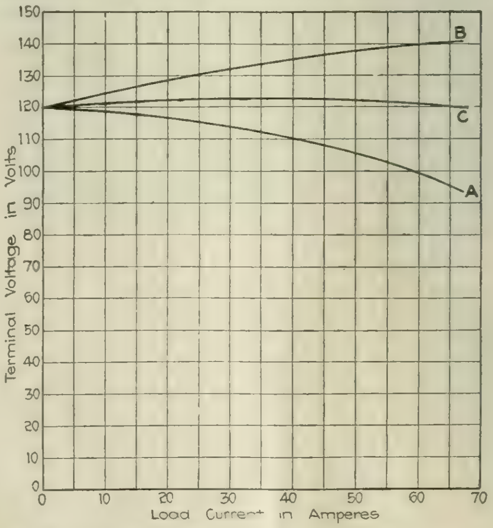


FIG. 2. DIRECT-CURRENT GENERATOR EXTERNAL CHARACTERISTIC CURVES

behavior of generators in parallel is therefore seen to depend upon the shapes of their external characteristic curves. If these are of the "rising" type, as *B*, the machines will not parallel without an equalizer, but if of the "drooping" type, as *A*, they will do so. Consequently, we find that as the steepness of the curve *B* decreases, the violence of the unbalancing previously described becomes less pronounced, until, when flat-componding, as illustrated by curve *C*, is attained, there is no serious unbalancing, and finally, when undercompounding is reached, there is none. The ultimate step in undercompounding is the complete elimination of series-field effect, which is equivalent to straight shunt operation as in *A*, and which is, as just shown, entirely successful.

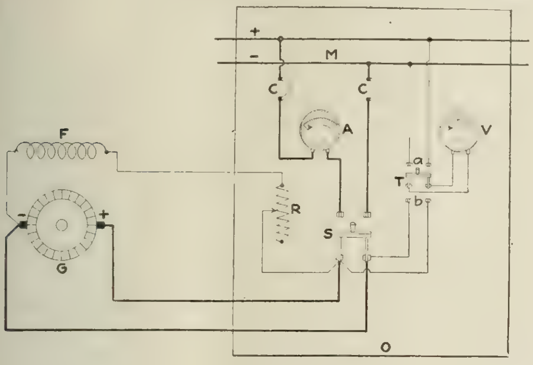


FIG. 3

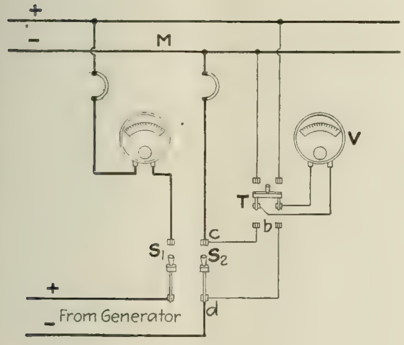


FIG. 4

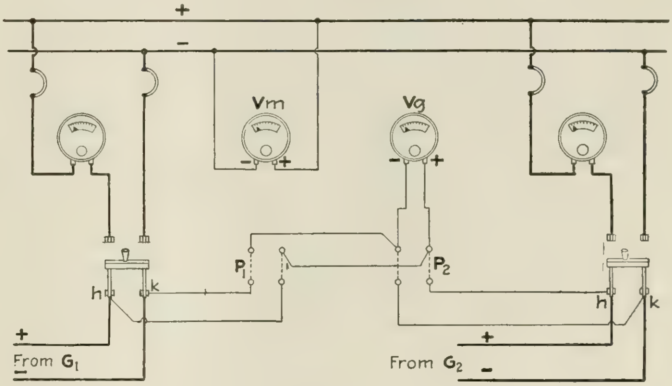


FIG. 5

FIGS. 3 TO 5. DIAGRAMS OF CONNECTIONS FOR OPERATING SHUNT-WOUND GENERATORS IN PARALLEL

There are a number of points that require attention when cutting-in a generator to operate in parallel with others and also when cutting-out one that is so operating. In the main the procedure for shunt and compound generators is the same, but there is some difference, and the two will therefore be treated separately.

In Fig. 3 are shown the connections of a self-excited shunt generator *G* that is part of a system of other generators connected to the busbars *M*. Within the outline *O* are represented the devices on the switchboard used in controlling it. They consist of the main switch *S*, which is of course open when the machine is not in service, the field rheostat *R* for adjusting the current through the field coils *F*, a voltmeter *V* connected to a switch *T* for obtaining the voltage at the busbars *M* and the generator respectively, an ammeter *A* for measuring the current output of the machine; and circuit-breakers *CC* to protect it against overload. We will assume that while the set is at rest it becomes necessary to place it in service, and follow the steps necessary to accomplish this.

The first thing to do is to start the unit and bring it up to normal speed, after which switch *T* is thrown to position *b* and the field current is adjusted by means of the rheostat *R* until the voltmeter *V* indicates approximately normal voltage. The switch *T* is then thrown to position *a* and the reading of voltmeter *V* is noted, upon which *T* is thrown back to *b* and the voltage of the generator adjusted to exactly the same value by further manipulation of rheostat *R*. Switch *T* is then thrown from *b* to *a* and back again to assure the operator that the two voltages are of like values, and if they are not quite so the rheostat *R* is manipulated until they have been made equal. The switch *S* is then closed, thereby connecting the generator to the mains *M*. If the voltage of the generator has been carefully adjusted to the same value as that of the mains, the ammeter *A* will indicate no current.

If the voltage of the generator was a little lower than that of the mains, the ammeter will show a reversed deflection, showing that current is being taken from the mains by the machine; and if the generator voltage was somewhat greater than that of the mains, the ammeter would indicate in the correct direction and its reading would be the current delivered to the system by the machine. These conditions follow from the relation $I = \frac{E_g - E}{R}$, where *I* is the generator armature current, E_g the open-circuit voltage of the generator, *E* the voltage of the mains, and *R* the resistance of the generator armature. From this it is seen that when *E* equals E_g we have $I = \frac{O}{R} = O$, when *E* is greater than E_g the value of *I* will be negative, and that when *E* is less than E_g the value of *I* will be positive. When *I* is negative it means that the machine is taking current instead of delivering it; that is, it is running as a motor and E_g is really the counter-em.f. Provided I is small, no disturbance will be created by the fact that the generator is running as a motor, since the direction of rotation of a shunt machine is the same irrespective of whether it is running as a motor or as a generator. When I is positive, it of course indicates that the machine is operating as a generator and delivering current to the system. Having connected the generator to the mains, it is then made to assume its share of the load by cutting out resistance in the rheostat R, thereby increasing the current through the field F, which in turn increases the magnetic field of the generator and so increases the generated voltage, thereby increasing the current. The resistance of the rheostat is reduced until the ammeter A indicates that the generator is delivering the current required of it.

When it is desired to remove a generator from the system, the resistance of the rheostat R is increased until the ammeter A reads zero current, showing that the voltage generated by the machine is exactly equal to the voltage of the mains. The switch S is then opened, disconnecting the generator, whereupon its prime mover is shut down and the unit is dead.

A slightly different arrangement of control is shown in Fig. 4. Instead of using the double-pole switch S of Fig. 3, two single-pole switches S_1 and S_2 are used, and the side b of voltmeter switch T is connected across the terminals of switch S_2 instead of as shown in Fig. 3. When it is desired to place the generator into service, it is started and switch S_1 is closed but not S_2. Switch T is thrown to position b and the field rheostat is manipulated until the voltmeter indicates zero voltage, when switch S_2 is closed. In this method it is not necessary to throw switch T from a to b and back to compare the generator and service voltages. When the voltmeter reading is reversed, it indicates that the generator voltage is too low, and conversely, when it shows a reading in the correct direction it is an indication that the voltage of the generator is too high. After switch S_2 has been thrown in, the load is adjusted in the same manner as previously described, and to remove the machine from service the procedure outlined before is likewise followed, except that there are two main switches, S_1 and S_2, to open instead of the one switch S of Fig. 3.

Often the double-pole double-throw switch T is replaced by a special plug switch. It is necessary to use a switch of that kind when a single voltmeter is installed on a switchboard that controls a number of machines. It is usual practice to install two voltmeters, as shown in Fig. 5, one of which, V_m, is connected directly to the mains and the other of which, V_g, can be connected to any one of the generators controlled from the switchboard by means of the plug switch provided for the purpose. There would be a set of switch contacts for each generator, such as P_1 and P_2 for generators G_1 and G_2 in Fig. 5, and the voltmeter circuit would be completed as indicated by the dotted lines when the plug was inserted into the contacts. There being only one plug, only one generator at a time could be connected to the voltmeter V_g, thus obviating the possibility of connecting any of the machines together through the contacts P_1 and P_2, which would cause serious consequences if the machines were not of equal voltages.

The details of paralleling compound generators will be taken up in the next lesson in the same manner as shunt generators have been treated of in the foregoing.

In the problem of the preceding lesson it was required to determine the values of the currents delivered by the generators whose external characteristics were represented in Fig. 1 of that lesson, when the total load was such as to cause the machines to deliver a terminal voltage of 110 volts. The curves are reproduced in Fig. 6, and to answer the question we follow the line corresponding to 110 volts until it crosses the curves; from the points of intersection we drop vertical lines and find at what number of amperes they cut the scale of load currents. These processes are indicated in the figure and give results of about 41.5 amperes for generator A and 22 amperes for B.

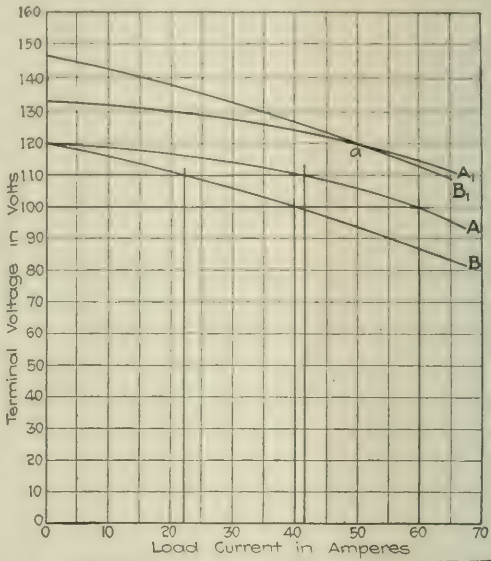


FIG. 6. EXTERNAL CHARACTERISTIC CURVES OF TWO SHUNT GENERATORS OF UNLIKE DESIGN

The second part of the problem was to show the position the curves would have to occupy in order that they should divide a load of 100 amperes at 120 volts between them equally. Since the total load is 100 amperes, each of the machines would have to deliver $\frac{100}{2} = 50$ amperes. In order that they should do so at 120 volts, their curves would have to pass through the point corresponding to 50 amperes at 120 volts, which is shown at a in Fig. 12. The curves would therefore occupy the positions of A_1 and B_1 as shown.

Two 100-kw. 230-volt shunt generators are operated in parallel. The armature resistance of each is 0.01 ohm. If the generated voltage of one was 234 volts and that of the other 233 volts, what would be the value of the current delivered to the load provided the busbar voltage is 230 volts?

Pat had got a job as a stoker on a ship, and, before starting, asked for a bucket of whitewash and brush.

"For what?" asked the chief stoker.

"Well," said Pat, "these submarines can see smoke a long way off, so I am up to them, for I always whitewash my coal before starting."

Making the CO_2 Recorder Pay Dividends

By M. A. SALLER

The CO_2 indicator or recorder does not of itself improve the efficiency of the plant, but merely shows what is being accomplished; hence, every engineer should be acquainted with the operation of the instrument, so that he may use the information it gives to aid in the economical combustion of coal.

TO SHOW the possibility for saving by more careful attention to combustion, take a set of operating conditions under which 15 per cent. of CO_2 is obtained, or practically perfect results. The loss in this case, assuming that the flue-gas temperature is 425 to 500 deg. F., is about 12 per cent., which is accepted as unpreventable because of the necessary heating of the flue gases to produce draft. However, if only a 10 per cent. CO_2 reading is obtained, the heat loss would amount to 17½ per cent., representing an excess over the unpreventable loss of over 5 per cent., while with only a 5 per cent. CO_2 reading the loss of heat in the flue gas would amount to 35 per cent., or a preventable loss of almost 25 per cent.

CAUSES OF LOW CO_2 READINGS

Low CO_2 reading may be caused by excess air, insufficient air or improper mixture of air and gases. Excess air may be caused by leaks in the boiler setting, carrying too thin a fire, holes in the fire bed or too strong a draft.

Leaks permitting the infiltration of air into the setting through the brickwork or doors can be readily detected by means of the old candle method. A lighted candle is passed slowly over the brickwork and door joints, and at those places where the leakage of air into the furnace is going on the flame will be drawn or sucked in. All these places should be chalk-marked and should then receive immediate attention. The holes and cracks should be plugged and calked with asbestos twine mixed with fireclay or some of the other commercial furnace calking materials or plastic cements. After the leaks have all been stopped, the whole setting should be plastered or painted with a thin coating of plastic airproof material. Leaks are particularly troublesome where door frames or supporting beams join the setting, and these points should have frequent attention.

DETECTING AIR LEAKS BY SMOKE METHOD

Another method of showing up air leaks is to start a brisk fire with green fuel while the dampers are open. Suddenly closing the dampers will result in confining large volumes of smoke within the setting, which will penetrate the larger cracks and crevices and show itself on the outside of the setting. This method will probably show up only the larger leaks and is not so effective as the candle method, though it is useful where a quick test is desired.

The next most important cause is the carrying of too thin a fire, which permits large quantities of air to pass through the fire and up the stack without participating in the complete scheme of combustion. This condition can be remedied either by reducing the amount of draft or by carrying a thicker fuel bed.

IMPORTANCE OF AN EVEN FUEL BED

Holes in the fire will naturally permit the infiltration of large quantities of air. This is usually due to careless or ignorant firing and the men should be instructed to carry a level and even fuel bed. Spotty fires are often caused by too frequent stirring and use of the fire tools. Where a clinker is caught in the grate and holds it open, the fire is liable to be burned through in advance of the other portions of the bed. If the clinker or ash clogs the grate and stops the passage of air, the combustion is reduced in the immediate vicinity while the inrush of air in other portions will quickly burn through the fire in spots. Even firing, with the minimum of shaking and handling, and the avoidance of clinkers will usually eliminate trouble of this nature.

It will be found sometimes that excess air is the result of using grates that contain air spaces too large for the size of fuel used, allowing the bed to fall through at some points, or else resulting in an uneven distribution of the fuel, through which thin spots the air will rush without being completely broken up.

Excess air may be caused by too strong a draft. This should be reduced or else the fire bed should be carried thicker. Often what appears to be excess draft is caused by the use of coal of uneven quality, the large lumps usually forming in such a way as to allow the air to pass too freely through that portion of the fire.

INSUFFICIENT AIR OR DRAFT CAUSES LOW CO_2

Low CO_2 is also caused by insufficient air or too little draft. The fuel bed may be too thick or the air spaces in the grate may be clogged with clinker or slag. Again, the air spaces in the grate may be clear but may still be too small or insufficient in number to pass all the air needed for proper combustion in the fuel bed. Leaks in the setting or flues beyond the combustion chamber help to cut down the draft. Dirty or clogged boiler tubes or flues and dampers retard the draft. If the chimney or flue is overloaded or too small for the volume of gases it is called upon to handle, there will naturally be a restriction of the draft. Where draft is insufficient the use of an auxiliary blower often solves the problem.

One of the most common causes of insufficient draft is the clogging of the grates with clinker or melted ash. Portions of the fire that have been turned over when the slice bar is being used are often so stirred up that ash finds its way to the top of the burning bed and under the intense heat melts and runs down on the grate, where it cools and forms hard clinker.

Excessive fusing of the ash depends on the quality of the coal. If the coal is high in sulphur, iron, alumina or silica, the fusing of the ash will usually be noticed.

Insufficient air follows when the fires are charged with too thick a layer of fresh fuel. When the thick cover of fresh coal is thrown on the fire, the air supply is momentarily restricted and the volatile gases driven off leave the fuel so rapidly that the supply of air is not sufficient to burn them completely. For this reason the fuel should be added in thin, even charges. In some cases it is desirable to arrange an auxiliary air inlet above the fire for admitting extra air to take care of these periods of probable shortage through the fuel bed.

Removable Truck Safety-First Switchboard Units

For use in electric-power plants the removable-truck type safety-first switchboard units shown in Figs. 1 and 2 can be obtained for the control of generators, motors and feeder circuits, and are particularly adapted to plants where electrical distribution to various buildings is made from economically located distribution centers. The construction is such that extensions to the switchboard can be made readily or the units removed to other locations to meet changed or new conditions. All live parts are inclosed, and the opportunity for an operator to come in contact with the circuit is practically eliminated. A spare removable unit can be used to reduce the time of shutdown for inspection or repairs. Busbars need not be killed, disconnecting switches need not be opened, leads and small wirings are not disturbed. The design of the unit is in accordance with the best engineering practice. The oil switches, busses and all live parts are in compartments. This tends to reduce fire hazard and limits disturbances to a single point.

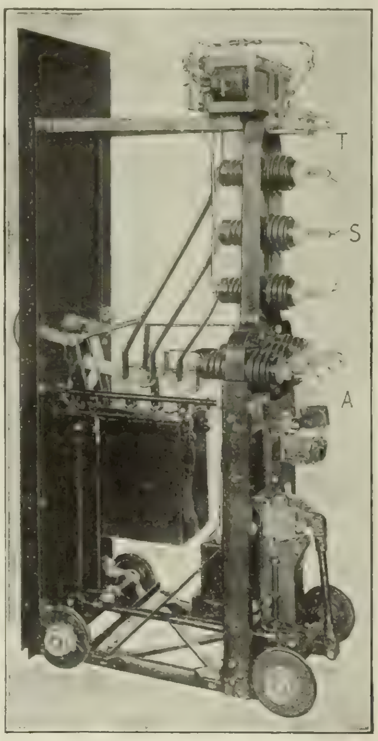


FIG. 1. REMOVABLE ELEMENT OF SWITCHBOARD

The stationary member *S*, Fig. 2, of the removable-truck switchboard carries current and potential busses, and their disconnecting switch studs and barriers between the current studs to prevent accidental contact by anyone who enters the compartment.

The rear end of the current disconnecting-switch studs in the compartment run to busses *B* and to incoming or outgoing leads; the potential bus wires to small contact studs near the top of the compartment. The side walls of the compartments are provided with handholes, so that the busbars and bus wires can be continued from unit to unit. On the exposed wall of the end units these openings can be closed by removable covers. Access to the rear of a compartment can be had by means of hinged sheet-steel doors provided with means for padlocking in the closed position.

The removable truck, Fig. 1, also shown in the foreground of Fig. 2, is mounted on wheels. The fore part carries a sheet-steel panel, on which are mounted the instruments, oil switches and other appliances usually mounted on the ordinary slate switchboard panel. The current transformers, when used, are mounted on steel brackets back of the instrument panel. The rear of the truck carries the movable parts of the disconnecting switches, the potential transformers and small wire accessories. The disconnecting switch to the busbar is shown at *S*, Fig. 1, and those from the outgoing circuit at *A*. The potential transformers *P* are mounted at the top of the rear of the truck, with their leads connecting to small disconnecting switches *T*. To center the truck and to assist in placing it in or removing it from the compartment rails fastened to the side of the compartment are furnished. The oil switches, instruments, transformers and all adjunct parts are removed entirely from the installation by wheeling out the truck. To remove or replace a switch unit, the oil switch must be opened, and therefore the load disconnected. This is provided for by an interlocking attachment to the oil-switch operating toggle which engages cast lugs on the walls of the stationary unit. With the oil switch closed it is impossible to remove or insert the truck. The value of this feature needs no discussion.

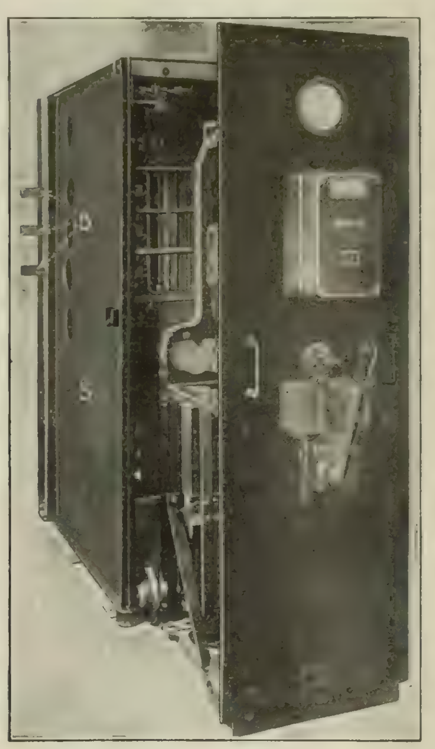


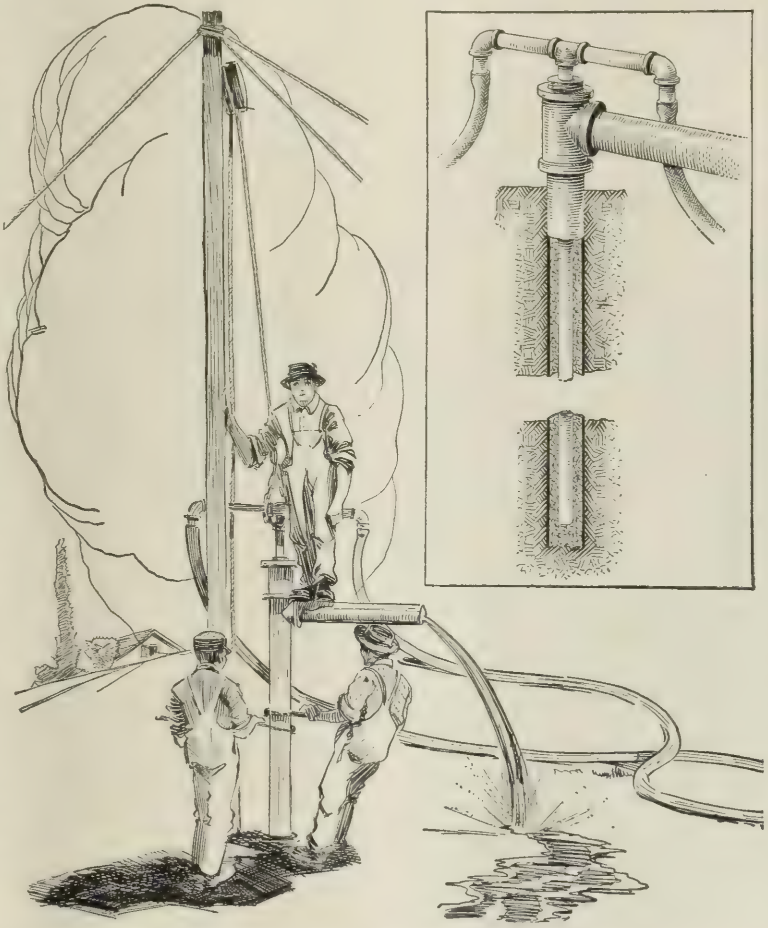
FIG. 2. SAFETY-FIRST SWITCHBOARD UNIT COMPLETE

The panels are manufactured in a variety of styles and capacities by the General Electric Co., of Schenectady, N. Y., varying from the smallest size up to and including 1200 amperes, and to operate at voltages up to 15,000. In the larger sizes the housings are usually of reinforced concrete, and all capacities are designed for use with either solenoid or manually operated oil circuit-breakers.

Drilling a Well by Hydraulic Pressure

By W. S. Heckendorn

Our experience in drilling a well with hydraulic pressure may be of interest to others. We first obtained an 18-in. well-drilling outfit and put down a test hole, in which we found fine sand and water at a depth of 6 ft. Then we connected a 3-in. centrifugal pump to the well and ran it for an hour without lowering the water. From the indications there was plenty of water, and we began to look for someone to put in a 12-ft. well down to coarse gravel, but the lowest bid was $1200. I advocated putting in points if we could get them, although it would require quite a number for a 165-gal. per minute pump. We finally got a price of $300 on 12 points. A 5-in. pipe was obtained for a casing, also a 5-in. tee. The pipe was cut so as to put a coupling 12 ft. from the tee. The tee was attached to the casing with the side outlet horizontal, and the top outlet was reduced from 5 in. to 2 in. A long thread was cut on a 12-ft. piece of 2-in. pipe so as to screw through the bushing from the under side. A tee was then screwed to the top end of the 2-in. pipe with a close nipple on each side, to which was screwed an ell and a nipple turned down for connecting two lines of 2-in. hose from the pump.



RIG FOR SINKING WELLS AND HOW IT WAS APPLIED

When all was ready, we ran two lines of 2-in. pipe from the pump to the derrick and attached the hose. A man was stationed on top of the discharge pipe from the side outlet of the 5-in. tee that was used to carry the water away from the well, and two pairs of chain tongs were used to turn the pipe from right to left and back, so as to give a cutting action in the ground. The idea is shown in the illustration. Then, dressed in a rubber suit to keep dry, the operator started the water. At first the water refused to run through the pipe, and the latter was lifted and the end cleaned out and then let down easily. When the water was turned on the pipe sank into soft black dirt at a rate of about a foot at a time. When sand was reached, we stopped to add another 12-ft. section of pipe. This was done by removing the 4-ft. length of discharge pipe and the hose, and the tee head was then unscrewed from the 5-in. pipe, and it, with the 2-in. length of pipe, was taken out, after which another 12-ft. length was added to both the 5- and the 2-in. pipe, and all was screwed together again. With this arrangement the stream of water from the hose washed out sand and gravel as fast as the pipes could drop to the hard ground, which was from 12 to 23 ft. below the surface. Some of the stones thrown out weighed as much as 7 oz. each. We put in eleven 4-in. by 6-ft. well points with sawed openings at each end for very fine sand and larger openings for coarse gravel in the 3-ft. length above the center of the points. They furnish all the water that a 165-gal. pump can handle. The pipe line is placed in a trench to within 18 in. of the water direct from the pump, with the crosses 6 ft. apart and the points 4 ft. from the line on each side, making them 8 ft. apart. The water is clear and cold all the year round, and tests 98 per cent. pure, although the city water, taken from the river, tests only 75 per cent. pure.

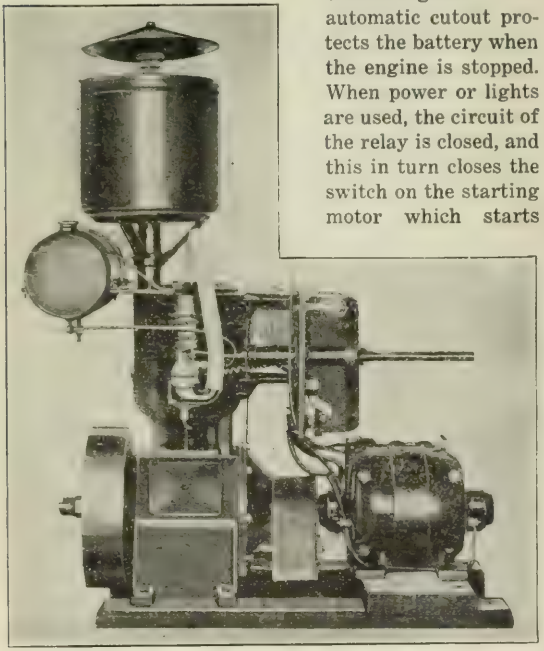
When the well had been drilled as far as was desired, we stripped the inside piping and uncoupled the 5-in. tee, measured the whole length inside with a ½-in. pipe and deducted the difference from the top of the casing to the right height of the pipe leading out from the cross connecting the strainer to the iron pipe, and then cut a thread for an ell. We next lowered the whole into the casing, then pulled the casing, leaving the strainer in the gravel, which we connected up with a flange fitting.

"Alco" Power and Lighting Plant

There are many places in which a small gas-engine-driven power and lighting unit can be used to advantage where steam is not available; such as for lighting buildings at a distance of, say, 1000 or 2000 ft. from the power plant, for small shops and for country and farm use. Such a power unit, known as the "Alco," is built by the Automatic Light Co., Inc., Minneapolis, Minn., and is illustrated herewith.

A single-cylinder four-cycle water-cooled engine is directly connected to a direct-current generator. The generator is duplex wound, having 110 volts on the power and lighting winding, and 7½ volts on the other, which is used as a motor for a 6-volt battery for starting the plant. When the engine is nearly up to speed, the 110-volt winding supplies current for light and power and the low-voltage winding acts as a generator and charges the starting battery.

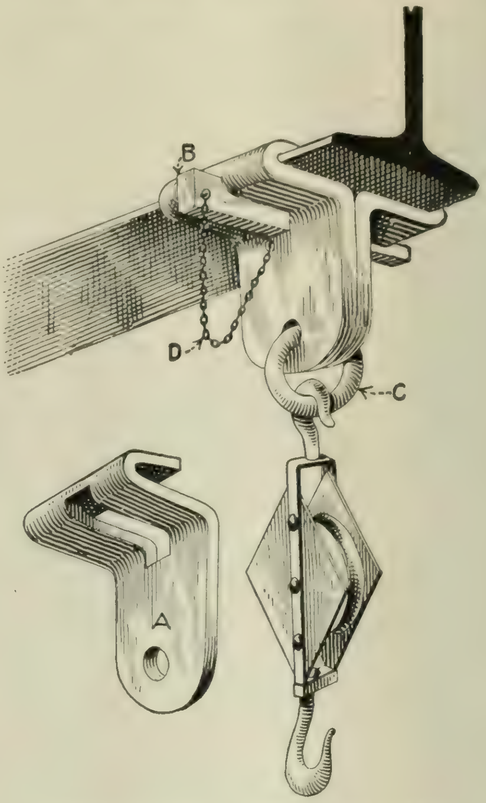
Upon a switchboard is mounted a relay and two electromagnets. An automatic cutout protects the battery when the engine is stopped. When power or lights are used, the circuit of the relay is closed, and this in turn closes the switch on the starting motor which starts the engine. When 90 volts are reached, the 6-volt current cuts out, and the 110-volt cuts in. The operation reverses when the last light or power motor is turned off, and the plant then stops. Voltage regulation is accomplished by an electric solenoid governor that acts directly on the throttle of the carburetor, opening and closing it to take care of the slightest variation in voltage.



COMPLETE POWER AND LIGHTING PLANT

Quickly Detachable Clamp

A quickly removable clamp which can be used anywhere about the place where I-beams are used is shown in the illustration, taken from *Coal Age*. The clamp is made of two sections of machine steel *A*, each being slotted to receive the taper key *B*. In operating the sections *A* are clamped tightly against the lower part of the beam by means of the wedge. The hanging ring is welded after passing through the lower holes of the sections. The holes should be large enough to allow free motion of the ring in order to permit setting and removing the hangers from the beam. For the sake of keeping all parts together, the key may be fastened to one of the sections by means of a small metal chain, *D*, as shown.



DETAILS OF EASILY DETACHABLE CLAMP

After all, what caused the war, or at least created conditions making it necessary for Germany to do something desperate, if it was not her vaunted foreign-trade policy of subsidies, credits, etc.? Any policy or transaction that is not in itself mutually profitable or beneficial to buyer and seller is bound to end disastrously if persisted in, and the more extensive the scale the greater will be the disaster. Germany for years had been guilty of "crooked" dealing and attempted to maintain her false position by a grand military campaign to ward off the inevitable commercial catastrophe. "Dumping," or selling goods below cost, cannot be carried on profitably, subsidies notwithstanding.

EDITORIALS

Metering the Air Supply to the Furnace

FROM the point of view of the fireman it is unfortunate that atmospheric air is invisible and so difficult to measure or to weigh accurately. It takes an active imagination to make a mental picture of air sweeping up into the furnace through the fuel bed, slyly slipping past the openings in the fire-door or sneaking stealthily through random chinks and porous brickwork.

Think of the simplicity of the problem of combustion if air could be as easily seen and handled as sawdust, and as readily weighed and measured! There would be no trouble at all in furnishing just the exact amount needed to burn each pound of coal to the best advantage, and if some of it tried to get inside the boiler setting in any way except through the approved channels, anyone but a blind man would be able to detect it.

But, as a former President once remarked, "It is a condition and not a theory that confronts us." Air must be recognized by its effects and not by its color or form or weight. No satisfactory method, applicable to the average boiler plant, has been devised whereby a definite quantity of air, by volume or by weight, can be metered on its way into the furnace. But though it is such a tricky, elusive gas before it combines with the fuel, it becomes fairly tractable and meek after it has been changed into carbon monoxide and carbon dioxide; for then it can be captured, put through the third degree and forced to reveal the information that is needed.

All this is accomplished by means of the flue-gas analyzer. That very useful instrument will take a gas sample and split it up, showing just what percentages of CO_2, O and CO it contains; and from such data it is possible to tell just how much air per pound of fuel has been admitted to the boiler setting. If the amount is excessive, that fact is at once apparent and the remedy can be applied.

Of course this method makes it necessary for the fireman to know how to handle the analyzer and interpret its readings; but that is a simple task as compared with the difficulty of trying to measure the air in pounds or cubic feet. And as the analyzer is destined to become more and more popular as a part of the equipment in the boiler room, firemen who neglect or refuse to learn the how and why of its action are blind to their own best interests.

It is not feasible to approach the air-supply problem from the front of the boiler, but it yields to an attack from the rear. It is practically impossible to measure air accurately and determine how much is going into the furnace; but after it has entered there is little difficulty in determining the quantity and the kind of associations it has formed and from them deducing the original amount of air that must have been admitted. This may seem like a roundabout way of getting the information, but it is the best that has yet been suggested and it produces the desired results.

More than once we have been called upon to calculate the weight of air required for the complete combustion of coal of a given composition, in order to satisfy some engineer or fireman who has been wrestling with the problem of burning coal economically. That information is readily obtainable; but we have always harbored a certain degree of curiosity as to what practical use was made of the figures thus furnished to the inquirer, and we have felt the temptation to ask him, in the language of a certain well-known cartoonist, "Now that you've got it, what are you gonna do with it?"

The Wage Problem

CONSIDERABLE newspaper criticism has appeared regarding Henry Ford, especially since his campaign for the United States Senate, and most of his motives and actions have been imputed to self-advertising. One item insists that this is so regarding the increase from five to six dollars a day in the wages of employees in his shops, to say nothing of his retirement from the presidency of the company in favor of his son Edsel, with a salary of one hundred and fifty thousand dollars a year. The item goes on to say that "only the Ford plant can afford to pay workers a uniform wage of six dollars a day."

Most men are misjudged when others reap some benefit from their actions, and it is difficult for the average business man to understand that there is reason or justice in paying men a wage of six dollars per day when their places can be filled with cheaper labor. The Ford plant is not the only one that can afford to pay a uniform wage of six dollars a day, although it may be the only one that realizes that the laborer is worthy of his hire. The average business man has not come to that way of thinking as yet, but the workingman has.

Wages and working hours are two great problems that will confront business in the future, and both will have to be recognized and satisfactorily settled. The recent strike of marine workmen in New York harbor may be cited. These men demand an eight-hour day and a twenty-five per cent. wage increase. After waiting for months for a settlement of their demands, they struck, and a complete suspension of river and harbor traffic was the result.

That the boat owners believe their men have been treated fairly is evidenced by the statement by one who spoke of a man who had been in his employ for a long period: "Why, we have taken care of Mr. Blank for about twenty years, and he has saved one thousand dollars." In other words, because Mr. Blank has worked for this boat owner twenty years he has been taken care of, and because he has been able to scrape together one thousand dollars, he has been receiving fair wages. If Mr. Blank had not been "taken care of" for the past twenty years, he might now be chief engineer of an ocean steamer, receiving a good salary.

The question of wages is here to stay. During the war workmen were able to command higher wages than had ever been paid before in this or any other country. Power-plant engineers have, of course, been benefited by a greater or less increase in pay, but not commensurate with what has been received by munition workers, carpenters and other trades, nor in proportion to the rise in the cost of the necessities of life.

The employer and employee must arrive at a wage basis before a satisfactory settlement can be had. The employer must recognize the fact that low wages are a thing of the past and that his employees are entitled not only to enough to live on but enough to live on in comfort and with something to put by for a "rainy day." On the other hand, the employee must realize that he is in justice bound to give one hundred cents' worth of labor for each dollar received in wages. When both parties get to the point where each recognizes that the other is entitled to fair and honest dealings, the problem of wages will be largely settled.

Doubtless the realization of this condition will be slow. But the fact remains that if a man is worth five or six dollars a day to the employer he should get it, and the employee should realize that if he is getting that amount he should make an equivalent return in labor.

With the war over and marine transportation getting back to normal, one wonders how many of those ten million rounds of ammunition the Mexicans want us to release to them will be used to shoot up the oil wells whose product American consumers are willing to pay well for.

Including in the cost of production or operation the interest on the total investment whether in use or not is unfair to the business and those carrying it on, both management and employees, as it always includes a lot of "bonehead" expenditures that have no legitimate place on the books as assets. If a plant has been poorly designed, the equipment ill chosen or some personal fad has caused abnormal expenditure, it should be charged off the books or the engineer should not be accused of incompetence if he fails to make a satisfactory showing. Idle machinery is idle money and should not be expected to produce revenue. There is also a withholding of money or investment that is not only unprofitable in itself, but keeps the capital already invested from being more profitable. A thoroughly well balanced plant, exactly suited to the purpose for which it is to be used, not too elaborate in its appointments or too scantily equipped, is indeed a rarity.

Electricity

The wish has often been expressed for a paper which would be to the practical electrician what "Power" has been to the operating engineer.

"Power" has made its success by telling the story of the power plant in everyday language that could be read and understood by the busy practical man who knows more about mechanics than he does about mathematics.

The power-plant engineer has become to a greater or less extent a practical electrician. "Power" is going to tell the story of electricity to him in the same practical, helpful, easily understandable way that it has talked steam engineering to the steam engineer; and practical electricians will find in it the paper which they have been needing.

Look at the electrical pages in this number. And there are just as many articles of other kinds as before. The number of reading pages has been increased to accommodate the greater amount of electrical matter.

If it is not just what you would ask for if you were writing the specifications, let us know how it can be made to suit you better.

A few months ago thousands of men left their jobs to fight for their flag and ours. Most companies put out service flags with a star for each man who left their employ to enter the service. Now when the men are coming back, how about their jobs? Do they get them, or will they have to walk the streets looking for others? At the least, a star should be removed from the service flag for each man who does not get his job back, as an employer has no right to display them and the men will not thank him for so doing.

Just what volume of air and what strength of draft must be used to burn any particular fuel in any given furnace can be determined only by actual trial and, being once determined, should be maintained as long as the particular fuel is used. Unfortunately, there are many engineers who pay no attention to the matter of draft and fuel, but are contented to maintain steam at the required pressure, regardless of how much draft is used or how much fuel is consumed in so doing.

One of our friends who is chief engineer for a large public-utility corporation was explaining to the company's chief counsel some of the principal things about certain engineering practice in power plants. "But," interrupted the counsel, "I cannot remember all that. Won't you get me a little book on engineering that will tell all about it?" "Certainly—on one condition," said the engineer; "that you get me one telling all about the law." Now there are some engineers just like that lawyer.

When boiler-feed water is heated by exhaust steam, a saving is made of about one per cent. of fuel for each eleven degrees Fahrenheit rise in the temperature of the feed water. One would not suppose that this is really known, judging from the volume of steam escaping from exhaust heads, and feed water going to the boiler at around one hundred and eighty degrees. A larger heater in such instances would be a money-saving investment.

With the passing of the emergency created by the war situation, water-power legislation in Congress should not be shelved; the need of hydro-electric development is little less than during the active period of the war.

Being in love with your work, outside of the mere matter of making it produce your daily bread, marks the difference between a weary grind and a fine job.

CORRESPONDENCE

Trouble with Belt Tighteners

We wish to thank you for publishing our belt-tightener problems in *Power* and to say that we have overcome the difficulty by turning off the crown of the pulleys. Using the straight-faced pulleys, which we now have, makes the belt run true.

Belt manufacturers also told us that part of the trouble was due to light belting. The wide belting is 48 in. wide and ⅜ in. thick, and the manufacturers think the belt stretches unevenly, making it run off, but as stated, since we have used straight-faced pulleys the trouble has disappeared. J. S. Eckert,

Blissfield, Mich. Continental Sugar Co.

Pump Valves Do Not Wear Well

In reply to Mr. Larsen in the issue of Jan. 7, page 30, I would suggest that the temperature of the heating returns varying from 60 to 180 deg. is the chief cause of the rubber valves warping and breaking. Rubber valves will not stand such variation in temperature and if Mr. Larsen will have the valve seats ground down or faced and will put in a set of brass valves, the cost will be more but it will surely pay in the end; that is, provided the other parts of the pump are kept in good condition. Patrick Molloy.

New York City, N. Y.

Boiler Horsepower from Metered Condensation

The first question answered on page 965 in the issue of Dec. 31 may be good engineering and strictly correct, but it is not what we find in actual practice or what would appeal to the average operator. Manufacturers of condensation meters are continually brought up against this question, and steam is not sold on the B.t.u. basis except in rare instances (we have never had one) as there are too many factors that may be in dispute. [The writer of the inquiry asked to have the horsepower figured and that it be based on the B.t.u.—Editor.]

The question generally is brought up as to whether they should use 30 lb. or 34½ lb. of water as the basic horsepower unit, and this is generally settled on the basis of the temperature of the returns and the actual boiler conditions as to feed-water heaters, and sufficient waste exhaust steam to produce the highest feed-water temperature at atmospheric pressure, with the result that 33 lb. is frequently called a boiler horsepower and agreed to as an arbitrary figure. Under usual conditions we would figure the boiler horsepower given in the question as follows: $1240 \times 8\frac{1}{3} \div 34.5 = 299.5$ boiler horsepower-hours, the weight of the water being considered as 8⅓ lb. per gal., owing to heat losses in returns and for which the steam producer is not willing to extend credit. We find few installations where measurement in gallons will be accepted [In this case the meter read gallons.—Editor], the approved form of meter dial registering in pounds and eliminating the heat factor. In order to get a reasonable value from the steam purchased, we recommend that a separator of ample size be installed to take out entrained water just before delivering to the consumer's premises and that piping, up to consumer's first take-off, be pitched back to this separator, which, combined with well-insulated steam lines, will eliminate losses to a considerable extent.

New York City. Theodore Haight.

[We are always glad to publish discussion letters giving various views on engineering subjects. The foregoing, however, deals with a matter that has been considered established ever since the Centennial Exposition in 1876, when the standard boiler horsepower rating was fixed as equivalent to the evaporation of 34.5 lb. of water from a feed temperature of 212 deg. F. to steam at atmospheric pressure, or an equivalent such as evaporating 30 lb. of water from a feed temperature of 100 deg. F. to steam at 70 lb. gage pressure. Tables of factors of evaporation have been worked out for a wide range of conditions of temperature and pressure, all based on the B.t.u. transmitted to the fluid as: $970.4 \times 34.5 = 33{,}478.8$ B.t.u. = one so-called boiler horsepower. It is best, however, to avoid the term horsepower, except as a generality, as an expression of boiler capacity or output, since the output of a boiler is heat energy that may or may not be converted into power, dependent on the use to which it is put.—Editor]

Saving by Lower Trap Discharge Temperature

In a plant in which there were several indirect heaters of seven sections each, two of the sections were arranged to be supplied with live steam, four with exhaust steam from the main engines, etc., and there was also a cross-connection by means of which live or exhaust steam could be supplied to the entire six sections, but the seventh section was supplied with exhaust steam from the engine driving the fan. The fan engine was discarded and a motor installed, and this seventh section was left "dead." To enable the heater to deliver enough heat when no exhaust steam was available, more steam at boiler pressure was used, but still confining it to the live-steam sections. At 100 lb. pressure the condensate left the trap at about 338 degrees F. and was lost.

A change was made by which live steam was admitted to all sections, the greater heating surface permitting it to be used at about atmospheric pressure. The condensate was discharged at about 212 deg., indicating a saving of about 126 heat units per pound of water. R. McLaren.

Toronto, Ont., Canada.

Generator Heats Excessively

A 125-volt 160-ampere direct-current generator in our plant heats excessively when loaded to only 90 amperes after a two hours' run, and the voltage drops. Is it possible that high-resistance brushes are the cause of the trouble? The brushes do not heat excessively.

I would like to hear an expression of opinion from *Power* readers as to the cause of this heating.

Gladstone, Mich. PETER BURKARD.

Motor Suddenly Reversed

In the electroplating department of our plant there is a 3-hp. 110-volt 2200 to 2800 r.p.m. direct-current shunt-wound motor without interpoles, driving a buffer. One morning after the motor had been running at full speed for about ten or fifteen minutes it suddenly stopped, reversed and ran in the opposite direction. A similar thing happened about two years ago. After shutting the motor down and making an inspection, the machine appeared to be in good condition and when again started operated without any further trouble.

I would like to know if any of the *Power* readers have had similar experiences, and to have an explanation as to what caused the motor to act as it did.

Pittsburgh, Penn. JOHN R. STEESKA.

Boiler Settings for Multiple-Retort Underfeed Stokers

It has just been called to my attention that Mr. Bromley in illustrating his article on "Boiler Settings for Multiple-Retort Underfeed Stokers" in the July 23, 1918, issue of *Power* used the form of setting which was designed by Vielé, Blackwell & Buck for the 1232-hp. marine type Babcock & Wilcox boilers at the new plant of the Appalachian Power Co., at Glen Lyn, Va. Although Mr. Bromley did not acknowledge the responsibility for this design, he was good enough to state that the design illustrated the most recent practice in boiler settings for underfeed stokers. In connection with this it might be interesting to call further attention to some of the features of the design which are considered to be some advance on prevailing methods. The illustration is from Mr. Bromley's article. The boiler proper is set quite a little higher than has been common practice. The stoker was moved back toward the bridge-wall several inches so that the inside line of the front furnace wall would be plumb. The bridge-wall also was made massive and as closely as possible a straight batter from bottom to top. A desirable improvement, we also believe, was the carrying of a double row of bonding tile at mid-height of the furnace walls around both the side and front. This design was worked out after consultation with the representatives of the Babcock & Wilcox Co. and the Westinghouse Electric and Manufacturing Co. and the examination of several similar settings which had developed weaknesses.

The installation of duplicate continuous spiral conveyors over the hoppers distributing coal from a bunker outside at the end of the building and in this way avoiding the usual overhead bunker, is a feature of the design.

VIELÉ, BLACKWELL & BUCK,
Consulting Engineers,
New York City. BY E. L. BROOME.

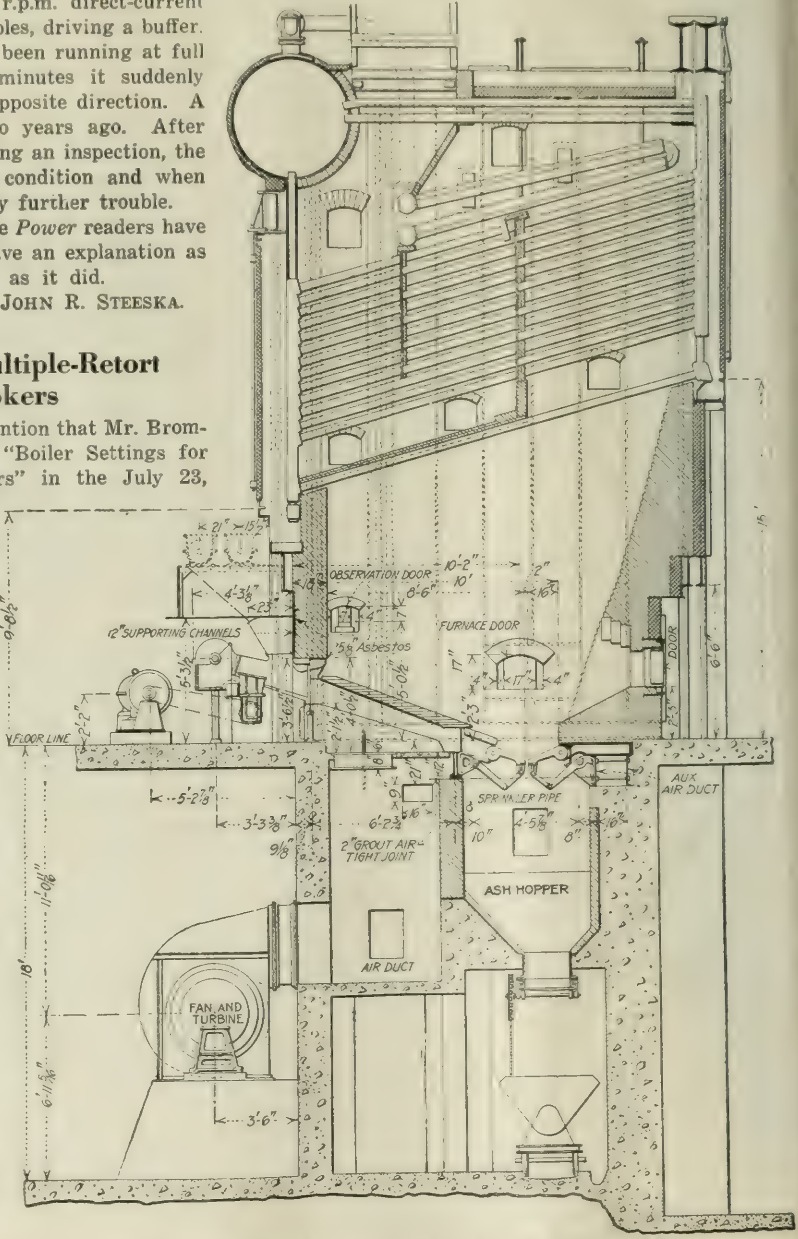


FIG. 1. LATEST TYPE OF SETTING FOR CROSS-DRUM BOILER

Observations of a Fuel Administration Inspector

I accepted the position of fuel administration inspector with some misgivings, as I had enough work of my own to do without bothering with other plants, but I am now glad that I did accept, because the knowledge gained was well worth the effort.

About the first plant that I visited was that of a large institution. The engine room was neat and the engines were running noiselessly. I first looked at the feed-water heater, the thermometer of which indicated a feed-water temperature of 210 deg., but when I put my hand on the feed pipe I found a considerable reduction in temperature. Upon looking the piping over to learn the cause, I discovered a ¾-in. water pipe with the valve full open and cold water going into the feed-pump suction pipe. The engineer said that he had to feed cold water so as to prevent the pump from getting steambound. I suggested changing the condition so that the pump would not get steambound, either by raising the heater (there was plenty of room) or by lowering the pump.

The engineer was of the opinion that open heaters were "no good," claiming that he never had seen one that did not give trouble. He said that he could not keep packing or valves in the pump for any length of time. I invited him to come to my plant where he would see a pump handling water at 214 deg. temperature, in which the piston packing and valves had not been touched for nearly a year, and cold-water injection is not used at that. Packing and valve troubles are largely caused by the changes of temperature to which they are subjected.

In the ice-machine room I noticed steam coming out of a well in one corner, and the engineer in answer to my inquiry said that it came from the generator steam trap. When I asked him why he did not return it to the feed-water heater, he replied that it was too long a run of pipe. He said that the generator operated at 11 lb., the steam being supplied through a reducing valve. I then asked why he did not use the exhaust steam from these pumps, and he replied there was no grease extractor or back-pressure valve. As a consequence the exhaust went to the roof.

Going into the boiler room I found 12 boilers in operation; a mixture of soft coal and No. 3 buckwheat was being used in the furnace. Opening the fire-door, I saw that the fire was about 18 in. thick and burning poorly. I called the engineer's attention to the condition, and he replied that he did not push them much on "days like this."

To regulate the feed pump the firemen had to go out in the cold and walk about 25 ft. to the pumproom. One can imagine the kind of regulation the pump got under the circumstances.

The soft coal was not broken up finely enough to mix intimately with the No. 3 buckwheat, and as the large lumps when thrown into the furnace lay there and did not burn evenly, the fuel bed was full of holes that required frequent raking to keep even. I will warrant that the plant was losing money instead of saving it burning that fuel under those conditions.

Brooklyn, N. Y. W. F. Remliw.

Switching Lighting Load from Two-Wire to Three-Wire Supply

A flour mill several blocks away from our power lines desired breakdown electrical service for use when the mill was shut down or at other times when the lighting generator might be out of order. The lighting system in the mill was two-wire 110-volt.

At first it was proposed to install a transformer near the plant, because the mill was a considerable distance from the nearest secondary line; also, the load would heavily unbalance the three-wire secondary system, as well as necessitate running heavier wires than if the high voltage was used. As the service would be required only a few times each month, a primary pole-top switch was to be installed so that by disconnecting it when not in use the transformer losses could be eliminated. It was finally decided to bring in the 110-220-volt three-wire secondary line from the street and change the wiring in the mill from two-wire to three-wire by running an extra feed wire from the switchboard to the different distributing boxes and distributing the load equally on each side of the three-wire feeder. A three-pole double-throw switch was installed, as shown in the figure, and the three-wire 110-220-volt service was connected from the city secondaries as indicated. When the switch is thrown to the street service a three-wire 110-220-volt system is obtained, and when thrown to the plant generator the three-wire system is cut over to a three-wire 110-volt distribution. As will be seen, the voltage is 110 from each outside to the center conductor, but zero volts between the two outside conductors when the switch is thrown to the generator.

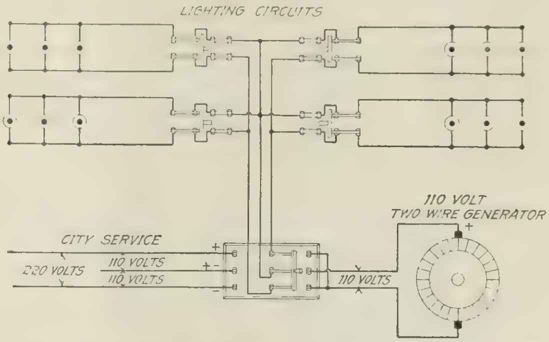


DIAGRAM OF CONNECTIONS FOR CHANGING FROM TWO-WIRE TO THREE-WIRE SERVICE

There are no doubt many installations where this method could be used to advantage, saving the cost of a transformer installation and possibly primary line extensions as well. G. M. Hardy.

Fort Monroe, Va.

Should Boilermakers Be Licensed?

On page 893 in the issue of Dec. 17, 1918, there appears an interesting letter by Mr. Sawyer, the opening paragraph of which states that in many localities plumbers are compelled to undergo examination and secure licenses and that the same rule should apply to boilermakers. Any boiler inspector of extensive experience can recall numerous instances of poor boiler repairs. In the country as a whole, nearly all insurable boilers are insured, and it is gratifying to note that there is a growing disposition among boiler men doing repair work to insist that an inspector precede or accompany the repair man on a job. This is to the interest of the owner of the boiler in that it often guards against unnecessary mutilation of the boiler, and to the boilermaker it insures against later adverse criticism of his work when the inspector sees it. Boiler inspectors are not "infallible," but they have not only their own judgment and experience to guide their decisions, but also the records of their companies and the advice of superiors.

The first step to be taken when repairs are needed, is to call for an inspector, and any reliable boiler insurance company is glad to answer such calls for special service. It seems hardly practicable to require boilermakers to secure licenses before being permitted to do repair work. The technical side of boilermaking is an extensive study in itself; therefore, to compel the boilermaker to master all the intricate technical details of the subject would seem to be quite too rigid a requirement. A short and effective way out of it would be to require that no repairs be permitted without investigation by a qualified state, municipal or insurance inspector. As an example, the best boiler repair man I have met is a man who can barely write his name—the simplest computation would defeat him—yet he has had many years' experience as a repair man and has made good use of his opportunity to observe cause and effect. He has carefully taken advantage of every opportunity to absorb practical ideas from all with whom he has come in contact; moreover, he refuses to touch a job on an insured boiler until the inspector has seen it. As a consequence he has a good reputation over a large part of four states and his services are in great demand.

There are many cases of "boiler mutilation" called necessary repairs, most of which are due to the penny-wise and pound-foolish ideas of the boiler owner, whose whole desire is to accept the lowest bid. The ability to answer technical questions would be no guarantee, but there can be no doubt that boiler work would be vastly improved provided none but licensed men worked at the job. Boilers would undoubtedly be made safer and some of the unnecessary repairs would be avoided, but the easiest and best way to secure maximum safety is to call in the inspector and abide by his decision.

Atlanta, Ga. **C. S. Regan.**

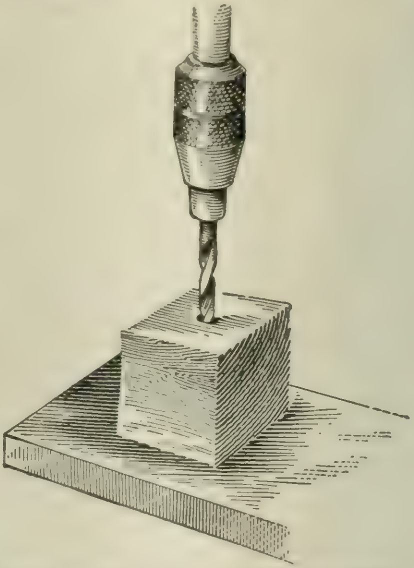
One will find poor workmen in all branches and trades, but that should not condemn all of them. If the engineers on the jobs referred to by Mr. Sawyer were licensed and let a boilermaker go ahead and do such repair jobs, then what good does licensing a trade do? An engineer certainly ought to know that a boiler with a lap crack on the longitudinal seam should be condemned at once and not let the boilermaker attempt to repair it. I have seen a 1½-in. pop safety valve connected to a boiler with a 1-in. nipple between, and the job was done by a licensed engineer. Unsafe repairs are sometimes made by engineers when in a hurry, that have nothing on the unlicensed boilermaker's worst.

I am not in favor of licensing boilermakers. Not that I think licensing them would do any harm, but because the work would not be any better than it has been in some cases where engineers are licensed. I certainly believe in good repairs and better workmanship, but I think unsafe and improper repairs would be fewer if engineers would use good judgment.

Olean, N. Y. **Charles W. Carter, Jr.**

Using a Small Twist Drill

When drilling a hard surface and using a fine drill, there is danger of breaking the drill, especially if it is high-speed and "wabbly" like a portable electric or air drill. To prevent breaking, take a small block of wood as thick as the length of the drill will allow and bore a hole through it the size of the drill or a little larger and place this over the drill. There is much less chance of buckling and breaking. **William H. Watson.**



GUIDE BLOCK TO STEADY DELICATE DRILL

Norristown, Penn.

Determining Polarity of an Electric Circuit

When it is necessary to find the polarity of any part of a circuit, the following method is simple and the means generally at hand, since most electrical men carry a blueprint of one kind or another in their pockets:

Wet a small portion of the print and hold the two ends of the wires about 0.25 in. apart on the wetted surface. The negative will show a decided white mark. It is advisable to take the current through a lamp in order to prevent a short-circuit, although I have often made the test without its use by separating the two ends of the wires by means of a piece of wood, then taping them securely together before turning on the current. **H. Wilson.**

Toronto, Canada.

Steam is generally used as a source of power for drilling oil wells, but pumping is usually done by gas or gasoline engines.

INQUIRIES OF GENERAL INTEREST

Removing Lime Scale from Injector—How may an injector be cleaned when it becomes clogged with lime scale? T. E.

The scale can be removed by soaking the injector in dilute muriatic acid, using about one part of acid to ten parts of water. If the injector cannot be cleaned in this manner sufficiently to make it operative, it will be necessary to take it apart and cleanse the parts separately.

Measuring Lead Opening—What is the best method of measuring the amount of lead of a slide valve? J. L.

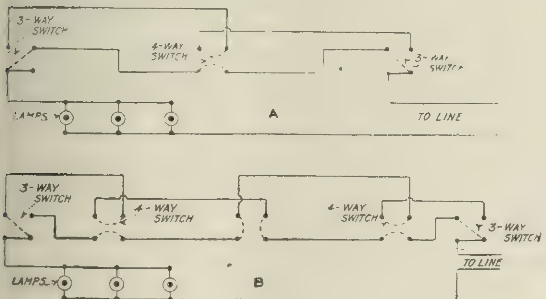
Place the engine on a center. The lead is most easily measured by pushing a wedge-shaped piece of soft wood in the valve opening. The edges of the valve and port will mark the distance and the thickness of the wedge at the marks is readily measured. If the valve and port edges are irregular or not parallel to each other, the average of a number of measurements should be taken.

Smoother Running by Cushioning on Exhaust—How is smoother running of a slide-valve engine obtained by cushion on the exhaust? W. T. R.

Cushioning on the exhaust results from closing the exhaust valve before the end of the stroke. The exhaust steam thus trapped in the cylinder is gradually compressed and acts like a cushion in gradually reversing the pressure on the crosshead pin and the crankpin, and thereby reduces pounding that may be caused by admission of live steam for the return stroke of the piston. The exhaust valve is made to close earlier by moving the eccentric farther around the shaft in the direction of the rotation. All valve events are thus made earlier in the stroke, and obtaining more compression of the exhaust is necessarily accompanied by more lead, earlier cutoff and earlier release.

Control of Lighting Circuit from Three Stations—What arrangement of switches is necessary to control a lamp circuit from three different stations? J. C. L.

To control an electric circuit from three stations, use two three-way and one four-way switches connected as in diagram A. The circuit may be controlled from any number of stations by using two three-way switches at the end stations and four-way switches at the intermediate stations. Diagram B shows the connections for controlling a circuit from five different stations.



3-WAY AND 4-WAY SWITCH CONNECTION DIAGRAM

Saturated and Superheated Steam—When is steam said to be saturated and when superheated? W. R. K.

By saturated steam is meant steam that is at the evaporation temperature corresponding to its pressure. When steam is formed in a boiler and rises from the surface of the water, it is "saturated" and will remain so as long as it is in contact with the water; and any attempt to heat the steam to a higher temperature will fail, as the heat so added is transmitted to the water and merely causes evaporation. Saturated steam may be perfectly dry, and when it holds particles of water in suspension it is said to be "wet." Unless otherwise specified, the quality is understood to be "dry saturated." To effect superheating, or raising the steam to a higher temperature than the temperature of saturated steam at the same pressure, the steam must be removed from close communication with water. The number of degrees by which the temperature exceeds the temperature of the boiling point of water corresponding to the pressure is called the "degrees of superheat," and this term is used to designate the amount of superheat. For example, if steam at a pressure of 100 lb. gage, or 115 lb. per sq.in. absolute, is found to have a temperature of 420 deg. F., then, as the temperature of the boiling point of water and of saturated steam at the given pressure is 338.1 deg. F., there would be 420 — 338.1 = 81.9, or practically 82 degrees of superheat.

Reversing a Two-Phase Four-Wire Motor—In a two-phase four-wire induction motor, which connections are changed to reverse its direction of rotation? Is there any difference in the way that a squirrel-cage type motor is reversed and reversal of the wound-rotor type? J. O. R.

Any two-phase motor can be reversed by interchanging the connections on either phase of the stator winding. This is indicated in Figs. 1 and 2. The connections of phase *A*, Fig. 2, are interchanged from that in Fig. 1, consequently will give an opposite direction of rotation. In reversing a two-phase wound-rotor type induction motor, change the stator winding connections as with the squirrel-cage type and do not change any of the rotor connections.

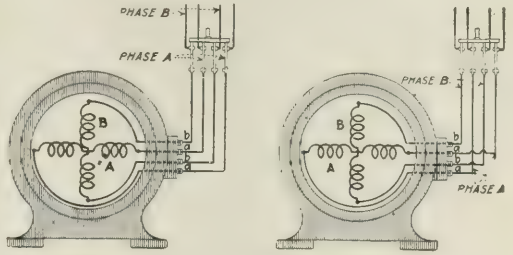


FIG.1 FIG.2

REVERSING TWO-PHASE FOUR-WIRE MOTOR

Pressure of Hydraulic Elevator Pressure Tank.—The pressure tank of a hydraulic elevator has a capacity of 1000 gallons and when two-thirds filled with water the pressure is 160 lb. per sq.in. The hydraulic cylinder is 18 in. diameter by 10 ft. stroke. How much pressure should the gage show after one full stroke? K. E.

Before the stroke takes place there would be 1000 ÷ 3 = 333.3 gal. or 333.3 ÷ 8.3 = 40.16 cu.ft. of space filled with air at the initial pressure of 160 lb. gage or 160 + 15 = 175 lb. per sq.in. absolute. Without any leakage one stroke of the hydraulic cylinder would remove from the tank $\frac{18}{12} \times \frac{18}{12} \times 0.7854 \times 10 = 17.67$ cu.ft. of water, and the initial volume of air would be expanded to 40.16 + 17.67 = 57.83 cu.ft. Assuming constant temperature, the absolute pressure would be inversely as the volume and after expansion of the air to the new volume the absolute pressure would be 175 × 40.16 ÷ 57.83 = 121.5 lb. absolute, or 121.5 — 15 = 106.5 lb. gage pressure.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Ammonia Condenser Data[*]

By HENRY TORRANCE
Vice President, Carbondale Machine Co.

This paper is to show that both the flooded atmospheric and the flooded injector types of condensers are wrong in theory and practice.

In the summer of 1914 the writer decided to test the value of the so-called flooded ammonia condenser, in which the ammonia vapor entered at the bottom and the liquid ammonia was drawn off at the top; also to ascertain if two coils in series, each with independent water supply, gave a still lower head pressure; that is, two coils were so connected that in one the ammonia vapor entered at the top and flowed downward, while in the other it entered at the bottom and flowed upward.

In Table I "flooded operation" means liquid taken off the top on both coils; "parallel operation" means liquid taken off the bottom on both coils, and "series operation" means liquid down one coil and up the other. The necessarily poor performance of the second coil cut down the results averaged over the two coils.

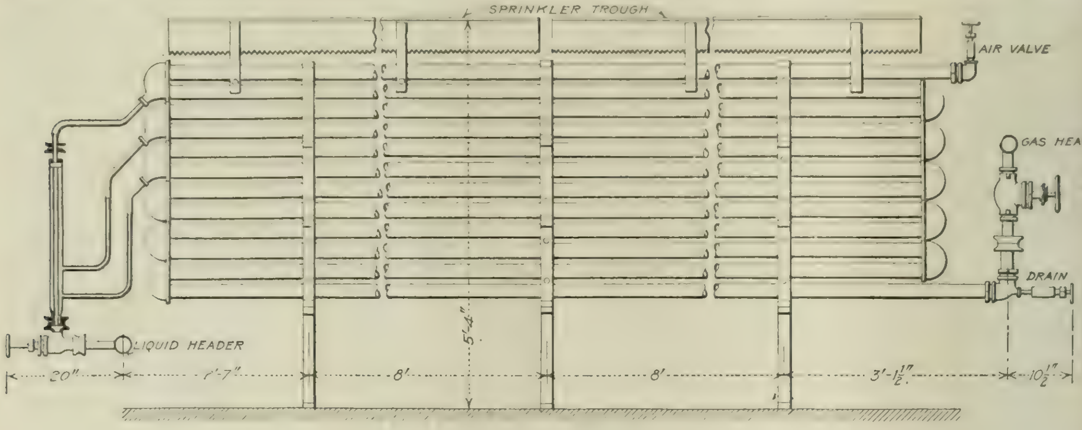


FIG. 1. DRIP-PIPE AMMONIA CONDENSER, CARBONDALE TYPE

An inspection of Table I shows that it made no difference how the ammonia ran, so long as the quantity of water and ammonia remained the same.

In November, 1915, the writer tested out the flooded injector condenser and found that the injector gave no appreciable advantage. See Table II.

ATMOSPHERIC DRIP OR BLEEDER TYPE CONDENSER

We concluded to test a drip condenser in which the liquid ammonia was drained off as fast as formed. We put a bleeder on each return bend and a valve on each bleeder. The coil tested was 2-in., 12 pipes high, 20 ft. long, and is illustrated by Fig. 1. The drip pipes were sealed as shown, so vapor could not bypass through the header, but would be obliged to pass up through the coil maintaining its velocity and efficiency.

We then made a comparative test of this drip condenser and the flooded injector condenser, which gave the results shown in Table III and Fig. 2.

From Table III and Fig. 1 it is apparent that with the same conditions of water supply and surface the drip condenser is decidedly better than the flooded injector type.

The theory of these flooded condensers, as the writer understands from their advocates, is that the water cools the pipe, the pipe cools the liquid ammonia, and the liquid cools and condenses the vapor. Let us consider the injector type of atmospheric condenser consisting of twelve runs of 2-in. pipe, 20 ft. long, total 150 sq. ft. surface and rate it at 20 tons refrigerating effect. The liquid must be cooled sufficiently low so that when it strikes the vapor it will condense it.

Thus, 20 tons at 24 lb. per hr. = 480 lb. per hr. ÷ 60 = 8 lb. to condense per minute, at 550 B.t.u. = 4400 B.t.u. per min. to be absorbed from ammonia vapor by the circulating liquid. If in doing this the liquid is raised 5 deg., the quantity of liquid circulating through the coil must be 4400 ÷ 5 = 880 lb. per min. = 176 gal., but we know 176 gal. could not flow through a 2-in. pipe under these conditions. Hence its temperature either rises considerably over 5 deg. or it does not condense all the vapor and carries much of it through the coil to condense gradually as in the ordinary condenser.

A paper was read before the Western Ice Manufacturers Convention at Kansas City on the "Economical Ice Plant of Today" and published in *Ice and Refrigeration* of April, 1915. In this the theory of this condenser was explained in the following words, referring to Fig. 3.

"The principle upon which these condensers are based is the condensation of a gas by introducing it into a body of its own liquid, and then cooling this liquid by passing it through apparatus where it comes in contact with a cool surface."

It does not seem possible that this theory is true, because the flooded system involves a triple cooling, the water has to first cool the pipe, the pipe cools the liquid, and the liquid should cool the vapor. Surely, if the pipe cooled the vapor direct it were better. We all know that ammonia under direct expansion gives a colder temperature in the room (provided the pipe contains no superheated gas) than first cooling brine and having the brine cool the room.

Furthermore, the argument that the heat transmission between liquid and liquid is better than between a vapor and a liquid (as advanced by these advocates of flooded condensers) is not necessarily true. If liquid has a poor circulation, its heat transmission may be as slow as 10 B.t.u., per hr. per. sq. ft. per. deg. difference in temperature.

Test of Shell Type Condenser: These two reasons convinced us that the above flooded system would be poorer, not better, so we put up in a test plant in Carbondale, a shell condenser, Fig. 4, connected so as to run empty, or flooded with an injector. We ran this condenser first empty, then flooded and found as theory would indicate, that the flooded system was worse, in fact very much worse, as shown in Table IV.

It does not take an expert to tell the difference; any one can see it with half an eye. Mr. Ophuls first pointed out to the writer that condensers should run empty, and the above experiments amply prove the theory. Mr. Greene substantiated the same thing and the discussion is given in A. S. R. E. *Transactions*, 1913, pages 71 to 74, which all interested should read again.

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[*] From the July *Journal* (delayed), American Society of Refrigerating Engineers.

The flooded condenser is wrong in both theory and practice. The flooded brine cooler is correct in theory because the liquid to be evaporated should touch the pipe. This flooded condenser theory was first brought to the notice of the Society at the December meeting, 1912, and was accepted as correct, and the false theory has been propagated all over the United States. The writer believes that it is time people should understand that the theory is fallacious, that the results per square foot of surface are poorer than in the ordinary type and considerably poorer than the drip type, besides requiring more ammonia.

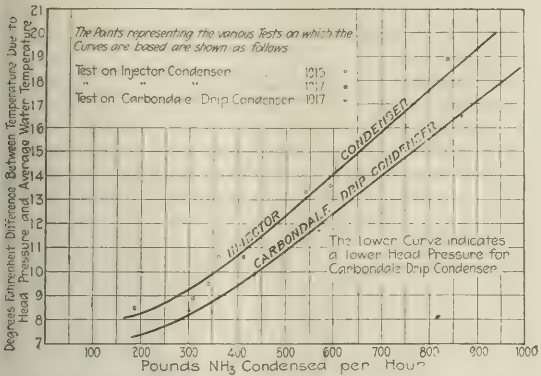

FIG. 2. CARBONDALE TESTS OF FLOODED INJECTOR TYPE CONDENSER AND OF DRIP CONDENSER

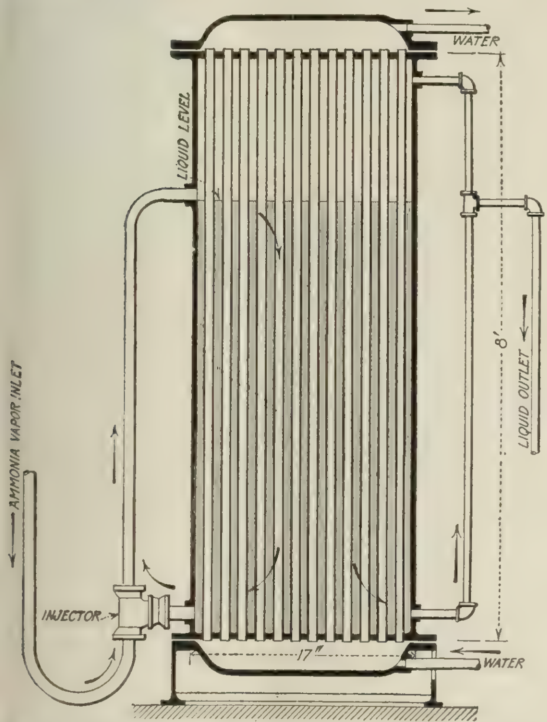

FIG. 3. FLOODED INJECTOR EXPERIMENTAL CONDENSER, SHIPLEY TYPE

In the discussion, Louis Block, inventor of the Block condenser, laid stress upon the value of high rates of heat transfer. Replying to Mr. Block, Fred Ophuls, of Ophuls, Hill & McCreery, consulting engineers, pointed out that the coefficient of heat transfer is not necessarily the most important factor in condenser design and operation, as regards efficiency.

Unfortunately, lack of space makes it impossible to give verbatim the discussion; some of the chief points are given, however.

Louis Block—To obviate the necessity of regulating (the gas flow to the condenser) I now build the condenser as shown in Fig. 5. The friction due to the lowest three pipes with their return bends is enough so that I can now leave the valve on the inlet pipe wide open, the hot gas header distributing the gas to all the condensers equally. At the fourth pipe from the bottom the pull begins, due to the counter-current. The gas wants to rush up to the top pipe of the condenser, and at the fourth pipe it begins to pull, but now the gas must overcome the friction in the three lowest pipes and their return bends. A 1¼-in. inlet pipe is just sufficient to supply to a condenser all the gas it can condense.

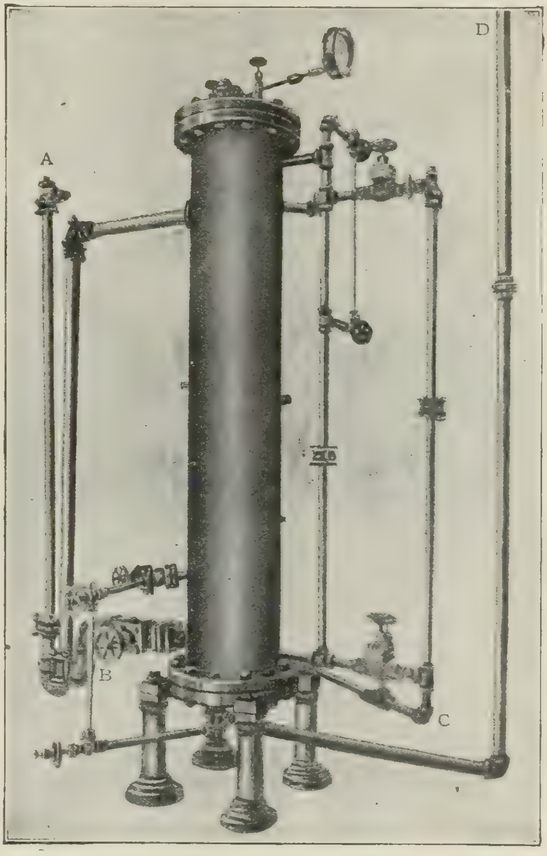

FIG. 4. EXPERIMENTAL VERTICAL SHELL CONDENSER
A.—Ammonia gas inlet. B.—Injector. C.—Liquid outlet. D.—Water supply.

In 1914 I tested a condenser, Fig. 6, which was provided with thermometers on the return bends. The condenser was 22 pipes high; the thermometer indications show what takes place inside the pipes. This condenser was built by the Vilter Company in 1910. The temperature of hot gas was 180 deg.; the temperature of the liquid was 80 deg.; the temperature of the water to the condenser was 72 deg.; the temperature of the water off the condenser was 90 deg.; the temperature in the third pipe was 92 deg. and it continued 92 deg. all the way up to the sixth pipe from the top; there it was 91 deg. In the fourth pipe from the top it was 90 and at the top it was 80 deg. So you see there is a condensing zone which stretches over 14 pipes in which

TABLE I. TESTS OF DOUBLE PIPE CONDENSER, FLOODED AND NOT FLOODED, 1914

Method of Operation	Tons Refrigeration by Brine 200 B.t.u. per Min.	Sq.Ft. Surface per Ton	Head Pressure, Pound Gage	Temperature Due to Head Pressure, Deg. F.	Water Inlet, Deg. F.	Water Outlet, Deg. F.	Liquid Ammonia, Deg. F.	Difference Between Temperature Due to Head Pressure and Water, Deg. F.: Inlet Col. 5 - Col. 6	Outlet Col. 5 - Col. 7	Average	Pounds Liquid Condensed per Hour Calculated from Tonnage	Water Per Min., Gal.
1	2	3	4	5	6	7	8	9	10	11	12	13
Flooded	19 0	7 0	125 0	74 3	60 1	66 0	71 1	14 2	8 3	11 25	475	76
Parallel	18 1	7 4	125 3	74 5	61 0	66 5	72 1	13 5	7 0	10 25	453	71
Series	19 0	7 0	126 [illegible]	75 0	60 4	65 9	70 3	14 6	9 1	11 85	474	76
Flooded	14 9	9 0	112 0	69 1	59 5	63 0	66 6	9 6	6 1	7 85	359	93
Parallel	9 6	14 0	110 6	68 0	60 2	63 2	66 5	7 8	4 8	6 30	238	90
Series	10 3	13 0	113 4	69 5	60 0	63.6	66 0	9 5	5 9	7 70	255	88
Series	11 9	11 2	114 0	69 8	60 4	64 4	65 6	9 4	5 4	7 40	294	57
Parallel	10 6	12 6	113 8	69 7	59 6	64 8	68 3	10 1	4 9	7 50	262	64
Flooded	9 6	14 0	114 0	69 8	60 0	64 9	68 0	9 8	4 9	7 35	237	56

Details of pipe of condenser as follows: Two coils, double pipe type, 1¼ in. and 2 in. pipes, each coil eight pipes high, 20 ft. long. Total outer surface of 16 1¼ in. pipes = 134 sq.ft.

TABLE II. TESTS OF FLOODED SHELL CONDENSER, WITH AND WITHOUT INJECTOR, 1915

Method of Operation	Sq. Ft. Condenser Surface	Tons Refrigeration by Brine 200 B.t.u. per Min.	Sq. Ft. per Ton	Head Pressure, Lb. Gage	Temperature Due Head Pressure, Deg. F.	Temp. Liquid Ammonia from Cond.	Condenser Water, Deg. F.: Inlet	Outlet	Range	Average	Difference Between Temperature Due Head Pressure and Average Water	Pounds Ammonia Condensed per Hour: Total	Per Square Foot	Per Sq. Ft. per 1 Deg. F. Aver. Temp. Diff. Water and Ammonia	Temperature Gas at Inlet	Water per Min., Gal.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
*	150	10 4	14 4	128 4	75 8	72 1	59 7	69 9	10 2	64 8	11 0	265 0	1 77	0 161	101 0	25 5
**	137	9 5	14 4	127 3	75 3	70 4	59 6	69 4	9 8	64 5	10 8	256 9	1 87	0 173	99 2	25 5
*	150	13 5	11 1	121 5	72 9	70 0	59 8	66 5	6 7	63 1	9 8	339 9	2 37	0 232	100 9	49 9
**	137	13 1	10 4	123 5	73 7	69 9	60 2	67 2	7 0	63 7	10 0	339 4	2 48	0 248	99 5	49 9
*	150	22 1	6 8	133 7	77 9	73 0	59 8	68 2	8 4	64 0	13 9	593 2	3 95	0 284	113 7	74 6
**	137	27 4	5 0	135 3	78 5	74 2	59 7	68 1	8 4	63 9	14 6	662 1	4 80	0 329	114 6	74 9
*	150	15 4	9 74	125 1	74 4	70 9	59 9	67 2	7 3	63 6	10 8	360 0	2 40	0 222	101 8	52 1
*	150	27 8	5 40	147 0	82 9	78 9	60 8	72 3	11 5	66 6	16 3	751 0	5 00	0 307	124 3	74 5
**	137	28 5	4 81	144 0	81 8	77 9	60 1	71 8	11 7	66 0	15 8	758 0	5 53	0 350	123 1	74 9
*	150	35 9	4 10	153 8	85 4	80 9	60 6	72 1	11 5	66 4	19 0	992 0	6 61	0 348	139 0	102 4
**	137	36 5	3 75	154 0	85 5	80 6	60 0	71 2	11 3	65 6	19 9	1012 0	7 39	0 371	135 0	103 3

* With injector ** Without injector.

TABLE III. COMPARATIVE TESTS OF FLOODED SHELL AND DRY ATMOSPHERIC DRIP TYPE OF CONDENSERS

Sq. Ft. Condenser Surface	Tons Refrigeration by Brine 200 B.t.u. per Min.	Sq.Ft. per Ton	Head Pressure, Lb. Gage	Temperature Due Head Pressure.	Temp. Liquid Ammonia from Cond.	Condenser, Water, Deg. F.: Inlet	Outlet	Range	Average	Difference Between Temperature Due Head Pressure and Average Water	Pounds Ammonia Condensed per Hour: Total	Per Square Foot	Per Sq.Ft. per 1 Deg. F. Aver. Temp. Diff. Col. 12	Temperature Gas at Inlet	Water per Min., Gal.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Flooded Injector Type, Vertical Shell Condenser, 1917.															
150	12 4	12 10	123 3	73 5	71 4	60 2	68 9	8 7	64 6	8 9	307 5	2 05	0 230	104 3	38 6
150	8 5	17 65	120.9	72 5	72 9	60 1	67 9	7 8	64 0	8 5	189 2	1 26	0 148	97 9	25 8
150	16 6	9 03	125 9	74 5	72 5	59 6	68 1	8 5	63 9	10 6	411 7	2 75	0 259	103 2	51.2
150	22 2	6 75	131 6	76 8	75 9	59 3	67 6	8 3	63 5	13 3	543 4	3 62	0 273	107 8	61 1
150	24 5	6 13	136 1	78 6	77 3	60 1	68 5	8 4	64 3	14 3	605 6	4 04	0 283	109 2	72 2
150	33 9	4 43	146.8	82 7	81 0	59 6	68 0	8 4	63 8	18 9	841 0	5 62	0 297	118 1	101 0
Atmospheric Drip Type, Condenser, 1917															
150	12 3	12 20	122 2	73 0	71 9	60 2	68 5	8 3	64 6	8 4	301 6	2 01	0.239	103 4	37 2
150	8 5	17 65	118 5	71 4	69 1	59 9	68 1	8 2	64 0	7 4	201 4	1 34	0 182	101 2	26 6
150	17 0	8 83	124 9	74 1	72 1	60 1	68.3	8 2	64 2	9 9	433 2	2 89	0 292	106 8	50.1
150	23.3	6 43	129 7	76 1	75 0	59 7	69 0	9 3	64.4	11 7	569 1	3 80	0 325	108 7	62 3
150	26.1	5 75	134 4	77 9	75 9	60 1	68 7	8 6	64 4	13 5	638 8	4 23	0 316	109 5	74 8
150	34.8	4.32	142 6	81 1	79 1	60 1	69.2	9.1	64.6	16.5	867 1	5.78	0.350	117 1	101.5

TABLE IV. TESTS OF VERTICAL SHELL CONDENSER, FLOODED AND NOT FLOODED

Sq. Ft. Condenser Surface	Tons Refrigeration by Brine 200 B.t.u. per Min.	Sq.Ft. per Ton	Head Pressure, Lb. Gage	Temperature Due Head Pressure.	Temp. Liquid Ammonia from Cond.	Condenser, Water, Deg. F.: Inlet	Outlet	Range	Average	Difference Between Temperature Due Head Pressure and Average Water	Pounds Ammonia Condensed per Hour: Total	Per Square Foot	Per Sq.Ft. per 1 Deg. F. Aver. Temp. Diff. Water and Ammonia	Temperature Gas at Inlet	Water per Min., Gal.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Shell Type Condenser, Flooded, 1917															
77	7 01	11.00	137 6	79.2	79 9	59.9	65.1	5 2	62 5	16.7	160.0	2 07	0.124	93 6	32 1
77	5.70	13.50	131.1	76.6	76.9	60.1	64.2	4.1	62.15	14.45	138.3	1.79	0.123	93.8	31.7
Shell Type Condenser, Not Flooded, 1917															
77	8 85	8 7	119.9	72 0	72 2	59 6	67 3	7 7	63 45	8 55	229 0	2 97	0 347	97.9	30.7
77	7 73	9 96	118 2	71 3	70 1	59 6	66 4	6 8	63 00	8 30	210 6	2 73	0 329	99 2	30 7

the temperature is exactly the same, while, of course, the temperature of the water changes; so there may be a heat transfer in some of these pipes which is still higher than the average heat transfer which I previously mentioned. *This condenser at the time did 56 tons of work per stand*, and that perhaps accounts for the rather high temperature of the discharged liquid, because it was forced some. There were two stands of condensers going with 150 gal. of water per minute showered over the two, and the water was heated 18 deg.; the machine was a Vilter compressor, 17 by 32 in., running at 60 r.p.m. with 21 lb. back pressure, doing 112 tons of work. The head pressure was 172 lb., which, according to Macintire, corresponds exactly to 92 deg. F., giving 18 deg. difference.

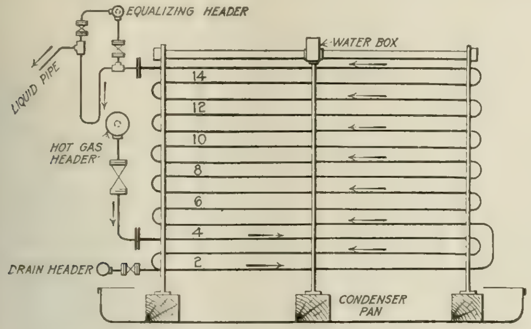

FIG. 5. CONNECTIONS TO THE PRESENT BLOCK CONDENSER

Mr. Block said that later experience has shown that it is unnecessary to make a condenser so high as 22 pipes.

F. L. Fairbanks—We have gone over our tests in the past year with three different types of condensers. One was the 1000-ton jet, another the injector shell, another was the so-called double-pipe flooded injector. The immediate effect in every case of introducing liquid was to run the head pressure up until enough had been injected to condense all of the gas, when it began to come down again. By figuring the difference in heat and allowing a reasonable temperature rise of the liquid, one would find that it took about 50 to 1. Our tests corroborate Mr. Torrance's results. In no case, even when pumping the liquid anhydrous ammonia through the coils at any velocity and in any known quantity, were we able to reduce the head pressure to that obtained with the dry type. In all three types of condensers, it went up from 8 to 20 lb. invariably, and we had all facilities for getting velocities and measuring quantities that it is possible to have, pumping the liquid with a double-acting Christine pump.

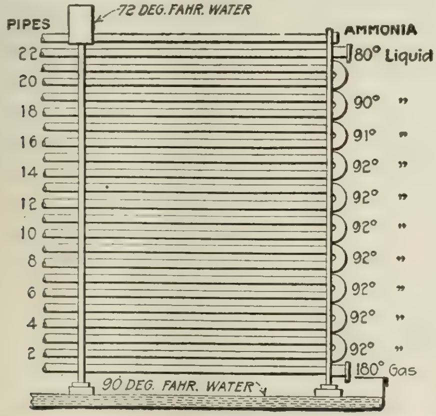

FIG. 6. MR. BLOCK'S 22-PIPES HIGH CONDENSER

We have found that at the ammonia condenser a foot of surface is the cheapest thing we have in our plant; it is the one thing that produces economy, particularly on large machines, so that we do not try to get the wide range Mr. Block speaks of. We keep our water temperature range between 5 and 10 deg., or 6 deg. usually. We find that when we get an increased range on the suction and the discharge side, we pay for it in the coal pile. The heat transfer per square foot of pipe can be made anything. If you increase the transmission per square foot of surface, you pay for it through the compressor to the coal pile. Power is a continuous process, and the investment in surface is an initial one. We make it a practice in our plant, and find it excellent economy, to use every foot of condenser surface available to secure the lowest possible head pressure. The result is that our compressors are much more efficient, require less horsepower, and operate with a more favorable volumetric efficiency, etc. In these respects we have not found any way of using the jet condenser so it will take the place of a surface condenser. In using a centrifugal wheel type of condenser, we found that the more nearly a dry surface and a high gas velocity is obtained, the greater will be the transmission per square foot and the more efficient is the condenser. Any collection of liquid on the condensing surface decreases directly the transmission of heat, because it acts as a blanket between the gas and the metal.

At this point Mr. Block mentioned that the high velocity in the Block condenser was responsible for its efficiency, whereupon Mr. Fairbanks and others contended that the high velocity was not had without cost in power and coal, inasmuch as velocity was had because pressure was converted to velocity. The discussion ended by Mr. Block inviting Mr. Fairbanks to set up a Block condenser and test it under Mr. Block's direction. Mr. Fairbanks accepted.

American Institute of Electrical Engineers

The American Institute of Electrical Engineers held its 345th meeting in the auditorium of the Engineering Societies Building, New York City, Friday evening, Jan. 10, 1919. Comfort A. Adams, president of the institute, opened the meeting by introducing Major General George O. Squires, Chief Signal Officer of the United States Army. General Squires presented his paper "Aëronautics in the United States, 1918," in which he reviewed the development of military aëronautics in this country up to the date of signing the armistice, Nov. 11, 1918. Some of the significant features brought out in this paper are as follows:

The War Department's first heavier than air flying machine was produced approximately ten years ago, but for the eight years that followed, less than $1,000,000 was appropriated for aëronautics. Up to June, 1918, approximately 1000 Liberty engines had been produced. By Dec. 31, 1918, more than 16,000 of these engines were manufactured. Up to the date of the signing of the armistice, Nov. 11, 1918, more than 14,000 Liberty engines had been produced, totaling 5,700,000 hp. So well recognized did the value of the Liberty engine become that at the time of the signing of the armistice the Allies had on order 16,741 Liberty engines and were constantly endeavoring each to increase their rate of monthly delivery.

The experimental development of the Liberty engine has been in charge of a department entirely separate from that dealing with its production. The work of this department has resulted in a continuous improvement of the power output and performance characteristics of the Liberty twelve-cylinder, to such an extent that 526 hp. have been obtained with special fuel and detail changes; certainly a remarkable increase from the 335 hp. which the original design was intended to yield. While the weight of the service engine per horsepower has remained at approximately 2 lb., the maximum present development had reduced this figure to 1⅓ lb.

In closing General Squires said:

"The Liberty engine stands today as an achievement which for daring, constructive imagination and farsightedness will ever be a cause of pride to the American people."

After General Squires presented his paper Captain Albro, of the Signal Corp, United States Army, gave a talk on the production of Liberty motors and airplanes in this country, which was illustrated with lantern slides and moving pictures.

The Engineering Index Now Conducted by the A. S. M. E.

The *Engineering Index*, published for 25 years in the *Engineering Magazine* and its successor, *Industrial Management*, and universally regarded as the standard index to engineering periodical literature, has been acquired by the American Society of Mechanical Engineers, and hereafter will be compiled and published by that society. The first issue of the *Index* under the new management appears in the January number of the *Journal*.

As heretofore, the *Engineering Index* will be regularly issued in three different forms: (1) As a part of the *Journal* of the society; (2) as a separate monthly publication for libraries or individuals desiring to clip the items for indexing purposes; (3) as an annual volume in which all the items for the year are collected.

The *Engineering Index* originated with Prof. J. B. Johnson, of Washington University, St. Louis, Mo., in 1883 and for 12 years was prepared under his direction and published by the Association of Engineering Societies. It was then taken over by the Engineering Magazine Co. of New York and has since had the personal attention of John R. Dunlap, the president of that company, who has found it to be a widely appreciated undertaking by engineers throughout the world. The development of his magazine in the specialized field of industrial management, however, made it seem desirable to place the *Index* in the hands of an engineering organization covering a broader field and serving engineers engaged in more varied activities. The society immediately recognized the opportunity extended and purchased the *Index*, thus bringing to the *Journal* the prestige, name and other rights and privileges of what has been regarded as the leading index in the field. This establishes the *Engineering Index* on a secure and noncompetitive basis as a logical society activity.

Through the facilities afforded by the magnificent library of the Engineering Societies, which regularly receives 1100 periodicals from all parts of the world, the society has unlimited possibilities in publishing the *Index*. These periodicals comprise one of the most complete collections of current engineering literature in the world—in not less than ten languages and received from 37 countries. The indexing of engineering articles can be best accomplished by a professional organization, and the society will consider it one of its greatest services to place at the disposal of engineers, through the *Engineering Index* in the *Journal*, the means for using the wealth of data and general information published from month to month in the world's technical press.

The plan of classification to be used is as follows: The articles are listed in the general field of engineering to which they belong, and are then grouped together under the particular branch of the general subject. The following classifications give an adequate idea of the scope of the *Engineering Index* as it will be carried in the *Journal:* Mechanical Engineering, 31 subheads; Electrical Engineering, 11 subheads; Civil Engineering, 9 subheads; Mining Engineering, 14 subheads; Metallurgy, 7 subheads; Aëronautics, 19 subheads; Marine Engineering, 4 subheads; Organization and Management, 13 subheads; Industrial Technology, Railroad Engineering, 15 subheads; Munitions and Military Engineering; General Science, 3 subheads.

One Combined Engineering Society

Practically all engineers are agreed that the engineering profession should be organized more closely than at present. Only by organized and combined efforts can tangible results be accomplished. It is now divided into civil, mechanical, electrical, chemical, mining and "what not" societies working independently.

A solution of the problem is that all of the present recognized societies get together and form one combined engineering society, keeping the following points in mind: (1) Do not destroy the identity of the present societies; (2) take the good points of the present societies, add what is new and desirable, and get rid of the undesirable features.

The work of the combined organization should be to supplement the work of the separate societies now existing, taking up questions that they are too busy to accomplish, and centralize others that can be accomplished better by combined efforts. Technical work, advancement of the arts and sciences, would be accomplished in each individual society as at present. The general society would take care of such subjects as status of the engineer, general welfare, professional ethics, employment agencies, relation of the engineer to the general public, social benefit.

There is now no organization in existence to do such work. Such organizations as were and are in existence were for winning the war. They have accomplished their purpose, but they are not organized and useful to do the work which the engineer needs and should demand. The time to do this is now. The reconstruction period is on. The engineer ought to be a large factor in this. He did well during the war, showing what could be done by coöperation. The momentum that has been gained should not be lost.

The Duluth Engineers' Club, after ascertaining the sentiment of various engineering societies and finding that an urgent desire in line with the foregoing exists, has unanimously passed a resolution favoring such organization and has appointed a committee to further that end and to compile complete data regarding the sentiment of the profession throughout America on the subject.

A request is made that engineering societies in general bring up this matter at their next meetings for a favorable expression in the form of a vote on the question and advise the Duluth Engineers' Club of the results. The committee consists of O. H. Dickerson, member of the American Society of Civil Engineers; F. S. Heald, member of the American Institute of Electrical Engineers; J. A. Graves, member of the American Chemical Society; F. H. Linley, member of the American Society of Mechanical Engineers; D. E. Woodbridge, member of the American Institute of Mining Engineers.

Soft-Coal Output Increased Six per Cent. in 1918

The lowest weekly production of bituminous coal reported in the last three years was brought about by the time lost on account of the Christmas holidays during the week ended Dec. 28, according to the Geological Survey. Estimates for this week place production at 6,385,000 net tons, 3,746,000 net tons, or 37 per cent. behind production of the week ended Dec. 21, and 3,352,000 net tons, or 34 per cent. behind production of Christmas week of last year. The average daily production (five days) is estimated at 1,277,000 net tons as compared with 1,913,000 net tons for this coal year to date and 1,763,000 net tons for the same period of 1917.

Total production of bituminous coal for the period Apr. 1 to Dec. 28 is estimated at 447,748,000 net tons, as against 412,561,000 net tons during the period Apr. 1 to Dec. 28, 1917, or an increase of 35,187,000 net tons.

The production of bituminous coal and lignite in the calendar year 1918 is estimated at 585,883,000 net tons, an increase compared with 1917 of 34,092,000 net tons, or 6.2 per cent. Four states reported decreases—Georgia, Iowa, Missouri and Texas. The most important increases were: Pennsylvania, 11,264,000 tons; Ohio, 5,715,000 tons; Illinois, 5,064,000 tons; West Virginia, 4,908,000 tons. The estimates indicate that West Virginia still retains second place as a coal producer, but the lead is so small that final returns may place Illinois in this position, which was assumed by the State of West Virginia in 1908.

The loss of time brought about by the Christmas holidays caused anthracite production during the week of Dec. 28 to decrease more than 500,000 net tons, compared with the production of the week preceding, and was approximately 200,000 net tons lower than the production during the corresponding week of 1917. For the period Apr. 1 to Dec. 28 the production of anthracite is estimated at 73,830,000 net tons which is 1,606,000 net tons or slightly more than 2 per cent. below the production of a similar period of the previous year.

Report of Fuel Administration on Liberty Fuel

Repeated requests for information regarding Liberty fuel have resulted in the issuance of the following statement by the Fuel Administration:

Tests made in the aëronautic laboratories of the United States Army resulted in information that the fuel was made up of approximately 65 per cent. of benzol, 25 to 30 per cent. of kerosene, and the remainder of a small percentage of amyl acetate and probably naphthalene and alcohol, together with, perhaps, small quantities of dissolved solids and other volatile liquids as yet undetermined.

On this analysis the available supply of the fuel must depend on the available supply of benzol, its chief constituent. Investigation showed that if the total production of benzol (3500 bbl. a day) were so used, the total production of Liberty fuel would be about 2 per cent. of the present output of gasoline, which is approximately 90,000,000 bbl. a year. Benzol, however, has other uses.

A gumming and corrosion test, also conducted in the aëronautic laboratories of the army, showed no perceptible corrosion, but a tremendous amount of gumming; that is, 0.4 per cent., accompanied by extensive fuming and penetrating odor. The tendency of the gummy residue in the fuel would be to plug up carburetors, Fuel Administration experts said.

In the same army-laboratory test, crystallization was found to be set in at 18 deg. F. and to be practically complete at 15 deg. F. Boiling started at 175 deg. F. as against an initial boiling point of not more than 140 deg. for motor gasoline indicating better starting qualities for motor gasoline.

The Bureau of Standards stated: "The results of tests in an aviation engine indicated that Liberty fuel compared with gasoline fulfilling the export specifications for aviation gasoline, will, when consuming 10 per cent. greater weight of fuel per horsepower, develop about 3 per cent. greater horsepower. The spark plug used in Liberty fuel showed a slightly greater carbon deposit than the plugs used in the run of export gasoline.

Information furnished the Fuel Administration by the Navy Department stated that a flight of forty minutes was made with the fuel, and that no observations were made which would show that the fuel would accomplish any other results than to operate the engine in a manner similar to the aviation fuel which had been used. Arrangements were made, the Navy Department reported, for sufficient quantities of the fuel to make fuel tests, but the fuel was not supplied.

A letter from Benedict Crowell, Assistant Secretary of War, said: "The situation has not reached such a stage that this office feels that any definite announcement can be made, or that it can express a definite opinion as to the true merits of the fuel.

The Bureau of Mines reported that it was approached, but, on asking for the formula in order to compound the material and being refused, dropped the matter, declining to act under the circumstances.

Personals

E. B. Mead, who for the last five years has been acting as salesman and efficiency engineer for the Vacuum Oil Co., has resigned and has accepted a position as assistant to the chief steam engineer at the plant of the Cambria Steel Co.

H. K. Gowdy, for many years chief engineer of the Pittsburgh Railways Co. and for the past three years in charge of the technical department of the Pittsburgh office of the Vacuum Oil Co., has been appointed chief steam engineer of the Cambria Steel Co.

Business Items

The Walworth Manufacturing Co., of Boston, has recently purchased the business of Hunter & Dickson Co. at 241-247 Arch St., Philadelphia, and will operate it as one of its branches.

The Quigley Furnace Specialties Co. has opened a branch office in Providence, R. I., at 302 Turks Head Building, in charge of F. W. Reisman, who has been the Quigley company's eastern New England representative for "Hytempite" (high temperature firebrick cement) and insulating brick as well as the air-transport system for distributing and burning powdered coal and other fuels.

Trade Catalogs

The Walter A. Zelnicker Supply Co., of St. Louis, Mo., has issued its Bulletin No. 250 for January, containing a full reference list of its supplies.

Tar Cameras for Colorimetric Tar Determination. Steere Engineering Co., Detroit, Mich. Bulletin No. 35. Pages 11, 8½ x 11 in. Illustrating and fully describing the process. Copy of bulletin free upon application.

Giant Semi-Diesel Fuel Oil Engine. Chicago Pneumatic Tool Co., Chicago, Ill. Bulletin 34-W. Pages 31, 6 x 9 in. Describing and illustrating this type of engine; horsepower ratings and general dimensions given in tables.

Space and Speed in Steel Buildings. Milliken Bros. Manufacturing Co., Inc., New York. Pages 23, 6¼ x 9¼ in. Describing the standardized truss unit system of building construction as designed and manufactured by this company.

The Tide Water Oil Co., of New York City, has recently issued a 100-page Veedol book on the "Lubrication of Internal Combustion Engines." This is the fourth edition of this book, revised and brought up to date, with additional chapters on airplane engines, farm tractors, grease and gasoline, as well as actual facts about lubricating oils for the layman and technical engineer. It is copiously illustrated and a copy will be sent free upon request to anybody interested.

Leeds & Northrup Co., Philadelphia, has issued a 60-page illustrated catalog No. 87, "The Potentiometer System of Pyrometry and Temperature Control," describing a system of pyrometry and temperature control in which the potentiometer method is employed for measuring the electromotive force of thermocouples. This catalog also gives a description of potentiometer indicators, curve drawing recorders, multiple-point recorders, temperature control apparatus, transformation point apparatus, precision potentiometers, thermocouples and pyrometers.

New Construction

PROPOSED WORK

Vt., Bellows Falls—The Bellows Falls Power Co. plans to build a hydro-electric plant at Pockhingham. R. Y. Fitzgerald, 50 Congress St., Boston, Mass., Secy.

Vt., St. Johnsbury—The Twin State Gas & Electric Co., 55 Congress St., Boston, Mass., plans a water power development on the Passumpsic River here. H. L. Olds, Vice-Pres.

Mass., Campello—A. E. Kieth & Co. will receive bids about March 10, for the construction of a power plant. Estimated cost, $56,000. Jenks & Ballou, 735 Grosvenor Bldg., Providence, R. I., Engr.

N. Y., Baldwinsville—The Seneca River Power Co. has increased its capital stock from $50,000 to $100,000 to provide for improvements and extensions to its plant. J. R. McIntyre, Supt.

N. Y., Buffalo—J. B. Laird, 747 Ellicott Sq., is in the market for three 200 hp., 150 lb. pressure boilers, or two 250 hp. boilers of similar type, also one 200 hp. motor, 25 cycle, 3 phase, 2200 volts, 500 r.p.m.

N. Y., Elmer—The Willys-Morrow Co. plans to build a 30 x 40 ft. addition to its boiler house. Estimated cost, $5000.

N. Y., Hoffman Island—L. E. Coffer, Health Officer, Port of New York, will receive bids until Jan. 25 for setting 2 boilers, etc., at the Quarantine Station, here.

N. Y., New York (Borough of Brooklyn)—W. Higgenson, Arch., 21 Park Row, Manhattan, will receive bids until Jan. 27, for the construction of a 1-story, 50 x 55 ft. power house addition on Classen Ave., for Julius Kayser, 45 East 17th St., Manhattan. Estimated cost, $60,000.

N. Y., New York (Borough of Queens)—The Board of Education, 500 Park Ave., Manhattan, will install a steam heating system in the 3-story, 105 x 108 ft. school, which it plans to build on Colonial Ave. between Livingston and Meteor St., Long Island City. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., Manhattan, Arch. and Engr.

N. Y., New York—The Beth Israel Hospital, 70 Jefferson St., will install a steam heating system in the 16-story, 175 x 200 ft. hospital which it plans to build on Livingston Pl. between 16th and 17th St. Total estimated cost, $1,000,000. Louis Abramson, 220 5th Ave., Engr.

N. Y., Thiells—Frank A. Vanderlip, Pres. of Bd. of Managers of Letchworth Village, will receive bids until March 4, for the construction of an additional power house and equipment, consisting of new boilers, piping, feed water heaters, feed water filter, feed water meter, feed pump, steam turbine, valves, etc.; also underground piping, with pipe ranging from 2 in. to 20 in. Total estimated cost, $300,000.

N. J., Laurel Hill—The Board of Chosen Freeholders of Hudson Co., Jersey City, has had plans prepared for the construction of a 100 x 185 ft. power plant here, to furnish county with lighting service.

N. J., Linden—The Transatlantic Chemical Co. will install a steam heating system in the 2-story, 100 x 150 ft. factory, which it plans to build. Total estimated cost, $100,000.

Penn., Harrisburg—Bernard Schmidt, 13th and Walnut St., plans to build a power house, in connection with the new baking plant.

Md., Glenarm—The F. H. Copper Co. is in the market for 75-hp. boilers.

W. Va., South Charleston—The Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will receive bids until Jan. 24 for installing 3 reversible and variable motors in the Navy Yard here; Schedule No. 7681½.

W. Va., Wheeling—The Wheeling Electric Co., controlled by the American Gas & Electric Co., 30 Church St., New York City, N. Y., plans to build a new electric plant. Estimated cost, $750,000. John B. Garden, Gen. Mgr.

Fla., Bradentown—The city is in the market for a steam driven air compressor or air lift pump and two 11 hp Westinghouse motors for operating a bridge.

Ala., Birmingham—The Alabama Canning Co. is in the market for 50-hp boilers and 12-hp engines. William C. Hale, Secy.

La., Homer—George Lewis is in the market for equipment for a power plant, grinding plant, etc.

Ohio, Cleveland—The Cleveland Telephone Co., West 3rd St. and Champlain Ave., plans to construct new building, installing duplicates of all apparatus and cutting over; also switchboards to handle 13,000 lines.

Ohio, Cleveland—The Woodmen of the World, c/o W. S. Ferguson Co., Arch., 1000 Euclid Bldg., will install a steam heating system in the 3-story, 80 x 130 ft. club house, which they plan to build on East 79th St. and Euclid Ave. Total estimated cost, $200,000.

Ohio, Toledo—The Standard Sanitary Manufacturing Co. is in the market for a hand power hydraulic press, having a capacity of 100 tons, for putting on and taking off car wheels.

Ill., Chicago—The Acme Steel Goods Co., 2324 Archer Ave., plans to build a 1-story boiler house, pump house, etc., in connection with the additional unit which it plans to build to its hoop mill on 134th St. and Indiana Ave. Total estimated cost, $30,000.

Ill., Chicago—The Art Metal Manufacturing Co., 514 South Green St., is in the market for a power bending machine to form tubes.

Ill., Chicago—The Trustees of the University of Chicago, 134 South La Salle St., plan to build an addition to the existing power plant, or a new plant on the Illinois Central R.R. tracts near 58th St. Estimated cost of new plant, $2,000,000.

Wis., Eau Claire—The Chippewa Power Co., incorporated with a capital of $200,000, plans to build a hydro-electric power plant and develop power on the Chippewa River.

Wis., Galesville—The Davis Mill Co. plans to build an addition to its power house, and is in the market for a 100 hp. engine. B. W. Davis, Mgr.

Wis., Janesville—The Board of Supervisors of Rock County plan to build a 104 x 116 ft. hydro-electric power plant near here. Van Ryan & DeGelleke, Caswell Bldg., Milwaukee, Arch.

Wis., Milwaukee—The Storage Battery Service Co., 137 Oneida St., plans to build a 1-story, 60 x 127 ft. service station at 596 Jefferson St. Estimated cost, $25,000. R. E. Oberst, 353 National Ave., Arch.

Wis., Portage—The Water Commission will receive bids until Jan. 31st. for installing 1 high pressure fire tube boiler, diameter 60 ft., length 16 ft., complete with front, grates, etc.; also to repair and re-flue the 2 boilers of the same dimensions now installed in the pumping station. H. V. Tennant, Supt.

Wis., Wausau—The Wisconsin Valley Electric Co. has had plans prepared for the construction of a power dam. M. C. Ewing, Mgr.

Iowa, Cedar Rapids—The Iowa Electric Co. plans to build a high tension line connecting its hydro-electric plant at Anamosa with the steam generating plant at Maquokato. John I. Reed, Gen. Mgr.

Ark., Little Rock—The Little Rock Railway & Electric Co., 115 West 4th St., controlled by the American Cities Co., is in the market for a 5000 kw. turbine, to be installed in its power house. C. J. Griffith, Gen. Mgr.

Mo., Excelsior Springs—The Excelsior Springs Light & Power Co. plans to extend its electrical system to Holt, Kearney, Lawson and other cities. George W. Irey, Ch. Engr.

Mo., Fulton—The Board of Managers of the State Hospital will apply to the Legislature for an appropriation for the construction of a new power house and equipment. Estimated cost, $67,000.

Mo., St. Louis—The American Packing Co., Garfield Ave., plans to build a 1-story, 42 x 70 ft. boiler plant.

Mo., Sikestown—The City Council plans an election in April to vote on a bond issue for the construction of an electric-light plant.

Okla., Kingfisher—The city will soon receive bids for electrical improvements. Estimated cost, $50,000. Black & Veatch, 507 Interstate Bldg., Kansas City, Mo., Engr.

Okla., Muskogee—The city plans to install new equipment in the pumping station in connection with the improvement it plans to the water-works. Estimated cost, $200,000.

Okla., Okmulgee—The Okmulgee Ice & Light Co., controlled through stock ownership by the American Public Service Co., is in the market for a 1250 kva. generator, two 100-hp boilers and other machinery. C. H. Kretz, Mgr.

Okla., Tishomingo—The city plans to build an electric-light plant. Estimated cost, $18,000. Address the Mayor.

Utah, Helper—The city plans to reconstruct the intake works and penstock for the municipal hydro-electric plant destroyed by the recent flood. Estimated cost, $10,000.

Ariz., Humboldt—The Humboldt Improvement Co. has been authorized by the State Corporation Commission to take a loan of $200,000 for the construction of electric-light and water plants to serve Humboldt.

Cal., Newport Beach—The Board of Trustees plans to build an electrically operated pumping plant in connection with the new municipal sewerage system. Total estimated cost, $173,000.

Ont., Holstein—Buller & Brebnor plan to install electrical equipment in their broom and handle plant and are in the market for motors, machinery, wiring and all general equipment.

Ont., London—E. V. Buchanan, Gen. Mgr. of the Utilities Comn., will receive bids about March 15, for the construction of an addition to its hydro-station. Estimated cost, $60,000.

Ont., Toronto—S. L. B. Lines, 243 College St., is in the market for a 37 in. foot-power squaring shears.

Alta., Grand Prairie—The Grand Prairie Electric Light Co. is in the market for a new engine and will install a new alternating current system.

Porto Rico, San Juan—The Aboy Vidal Co. plans to build 3 warehouses, 3 stories, 100 x 150 ft. each; also docks here. A steam heating system will be installed in same. Total estimated cost, $3,000,000. J. M. Carver, 29 Broadway, New York City, N. Y., Engr.

CONTRACTS AWARDED

N. Y., New York (Borough of Bronx)—The Board of Education, 500 Park Ave., Manhattan, has awarded the contract for the installation of heating and ventilating systems in P. S. 32, to Daniel J. Rice, 103 Park Ave., Manhattan. Estimated cost, $62,797. Noted Jan. 2.

N. Y., Wards Island—L. F. Pilcher, State Arch., Capitol, Albany, has awarded the contract for installing coal and ash handling equipment, consisting of conveyor, coal hoppers, apron feeders, coal crushers, motors, etc., in the Manhattan State Hospital, to the Gifford Wood Co., Hudson. Estimated cost, $45,950.

Md., Dickeyville—The Baltimore County Water & Electric Co., 100 West Fayette St., Baltimore, has awarded the contract for the construction of a 1-story, 35 x 45 ft. pumping station, to the Price Construction Co., Maryland Trust Bldg., Baltimore. Estimated cost, $15,000.

Md., Westminster—The B. F. Shriver Co. has awarded the contract for the construction of a power plant, to J. F. Roystone Engineering Co.

Ohio, Cleveland—St. Casimir's congregation, 8223 Sowinski Ave., has awarded the contract for installing a heating system in the new 2-story church which it plans to build on East 82nd St. and Pulaski Ave., to the Price & Welker Co., 707 Canal Rd. Total estimated cost, $250,000.

Mich., Detroit—The U. S. Lighthouse Service, 341 Post Office Bldg., has awarded the contract for furnishing 2 Scotch type marine boilers for lighthouse tender "Amaranth," boilers 10 ft. 6 in. in diameter and 10 ft. 10 in. long, to the Lake Erie Boiler Works, 254 Perry St., Buffalo, N. Y. Estimated cost, $28,000.

Mich., Saginaw—The city has awarded the contract for installing 2 electrically driven pumping units, 3 transformers and accessories at the West Side water-works station, to Allis-Chalmers Manufacturing Co., West Allis, Wis. Estimated cost, $5800. Noted Jan. 7.

N. D., Elgin—T. R. Atkinson, Consulting Engr., has awarded the contract for building 50,000 gal. steel tank on a 100 ft. steel tower, to James Kennedy, 97 Broadway, Fargo. Pumping machinery and wells will be installed in same. Estimated cost, $30,000

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.10	Boiler	$2.65
Rice	2.90	Barley	2.40

All rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10, other rates p. 95

POWER

Volume 49 New York, January 28, 1919 *Number* 4

Increasing Efficiency at No Expense

JUDICIOUS use of commendation for work well done is a powerful aid in maintaining the spirit and good will of the members of an organization as well as in increasing the efficiency and the output; yet there are literally thousands of men in positions of authority who are utterly blind to the value of this instrument in their hands, if we may judge by their failure to use it.

The man who is absolutely callous and unresponsive to a word of praise for the performance of a good piece of work has yet to be discovered. Natural modesty may prevent an individual from openly showing that he is pleased, but there is no way by which he can disguise or ignore the warm glow that thrills through him when he hears words of approval. Human nature loves lip-homage.

No class of worker is immune from the effects of a complimentary remark. The superintendent may wear a silk undershirt and the fireman may cover his torso with red flannel, but beneath the skin they are both human and therefore equally susceptible to the magic of an appreciative look or word. If the board of directors, at the annual meeting, passes a resolution congratulating the superintendent on the showing he has made during the year, he carries that congratulatory letter around in his pocket and shows it to his intimate friends until it becomes worn at the creases and frayed at the edges; moreover, he goes at the work of the new year with an increased determination to improve on his already good record.

Similarly, if that same superintendent pauses on his way through the plant to tell the fireman that he has been right on the job and doing fine work, according to the figures on the daily report sheets, that fireman involuntarily suffers an increase of chest expansion measurable in inches and the chances are that he goes home and tells his wife that his boss has at last discovered his abilities.

Recognition—that is the whole matter in a nutshell. To a greater or less degree we all like to attract attention to ourselves or to our achievements. One of the most discouraging and depressing things in the world is indifference. But when to indifference is added routine work of an unattractive and oftentimes laborious nature, we have a plausible explanation of the lack of interest and the general low efficiency in many branches of industry.

There are employers and chiefs who never praise the meritorious efforts of subordinates. Just why they should be so chary of approval is a mystery. If a few well-chosen words of tribute required the spending of money or involved a lowering of prestige or influence, withholding them could be understood; but they cost nothing and their influence is beyond all calculation. To many a man, weary with repetition of the same motions and the same round of duties, they come like a refreshing breath of air and they act as a pleasing stimulus to better performance.

There may be excellent reasons why it is impossible to increase the pay of an employee who has accomplished praiseworthy results, but there is no excuse for failure to show recognition of his services when they are unusual in quality or value. More than that, the time to speak the "Well done!" is now. If a man deserves praise for what he has produced, let him know it while he can hear the sound of your voice. Eulogies do not penetrate very far within coffin walls.

BY RUFUS T. STROHM

Pumping Plant and Electrical Equipment at Balboa Shops, Canal Zone

By R. D. Gatewood*

THE pumping plant for the 1000-ft. drydock at Balboa, Canal Zone, has now been in operation for over two years and has proved itself to be eminently well-suited for the purpose, practically no material changes having been found necessary in the original plans for design and installation. The plant consists of four main pumps and two drainage pumps and one bilge or seepage pump located in a well near the entrance of the dry dock. These are installed in the building shown in Fig. 1, which also houses both the electric and steam air compressors.

The main pumps and drainage pumps, shown in Fig. 2, draw water from a suction chamber below the level of the dock floor, the latter through a separate duct below the level of the floor of the suction chamber. The bilge pump draws water from the pump well itself. All these pumps are operated on 2200-volt three-phase 25-cycle current. The main pumps have a capacity of 11,000 cu.ft. of salt water per minute against a head of 48 ft. This head exists when the pump is drawing from the bottom of the dock, which is at minus 39, and discharging against average high tide, or plus 8.5. Conditions may arise, however, when the pumps will be required to discharge against a tidal elevation of plus 13.

The drainage pumps are supplied for unwatering the suction chamber of the main pumps and for removing leakage, waste from ships in the dock, etc. These pumps are capable of discharging 1200 cu.ft. of water per min. against a head of 43.5 ft. and are equipped with both hand and automatic control, the latter being arranged so that whenever the water rises to a depth of 10 ft. in the suction chamber, the pumps will automatically start and operate until the chamber is empty. The bilge pump is required to empty the lowest part of the pump well at any stage of the tide and has a capacity of 25 cu.ft. of water per minute. This pump also is fitted with hand and automatic starting and stopping equipment.

The main pumps are vertical units driven by 1000-hp. motors. The discharge opening as well as the suction is 54 in. in diameter. The drainage pumps also are vertical units driven by 200-hp. motors, with discharge and suction openings 20 in. in diameter. Each of the foregoing units consists of a vertical-shaft, single bottom suction, single-impeller volute centrifugal pump direct-connected to the vertical motor shaft. The bilge pump is a 3-in. centrifugal pump driven by a 25-hp. motor.

The compressed air for use throughout the Balboa shops is supplied by two electrically operated Ingersoll-Rand compressors, one 40 x 25½ x 30 in. with a capacity of 5000 cu.ft. of free air per minute, and the other 28 x 17½ x 21 in. with a capacity of 2252 cu.ft. of free air per minute, delivered at a pressure of 105 lb. These machines, shown in Fig. 3, are driven by direct-connected synchronous motors operating on 2200-volt three-phase 25-cycle current. The larger machine has a 1016-hp. motor and the smaller a 460-hp. motor. The compressors are equipped with the Rogler plate valve and therefore operate at considerably higher speeds than has been possible for machines of the same size heretofore. They make 136.3 r.p.m. and 185.5 r.p.m., respectively, for the large and small machine. Each machine is two-stage and is fitted with an unloader by means of which it can be operated at no load, or at one-quarter, one-half, three-quarters or full load. The unloader works automatically so that the motor takes only enough current to maintain the required pressure in the distributing lines. The motors are operated at 75 per cent. leading power factor for improving the factor in the transmission line.

The plant is located in the combined air-compressor and pump plant on the south side of the dry dock, and distributing lines are run around the head of the dock to the shop mains as well as along the wharves and to the coaling plant.

The electric power for the whole Canal Zone is generated in the hydro-electric station at the spillway for

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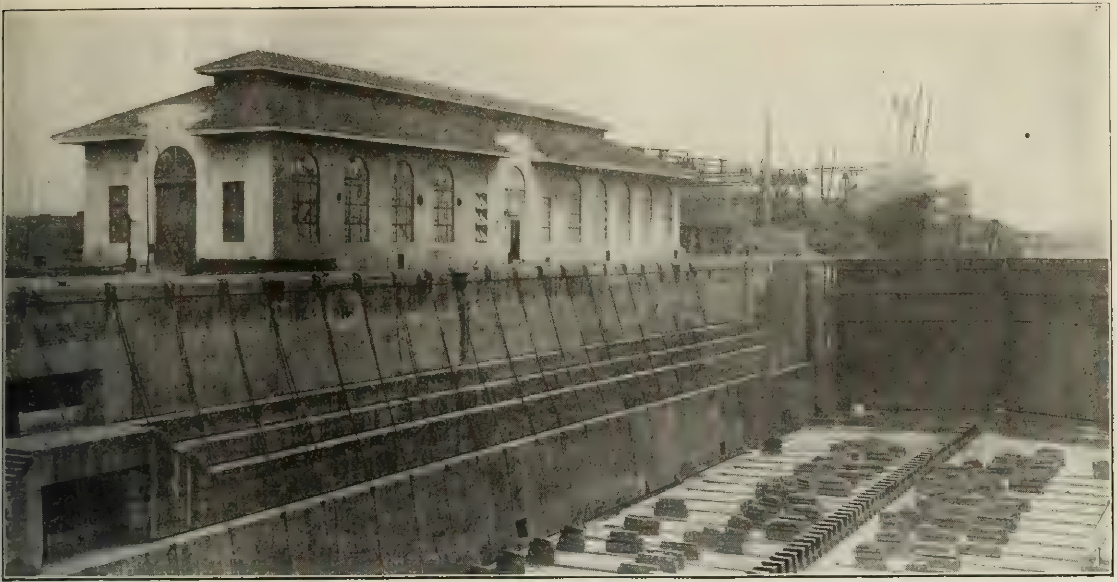
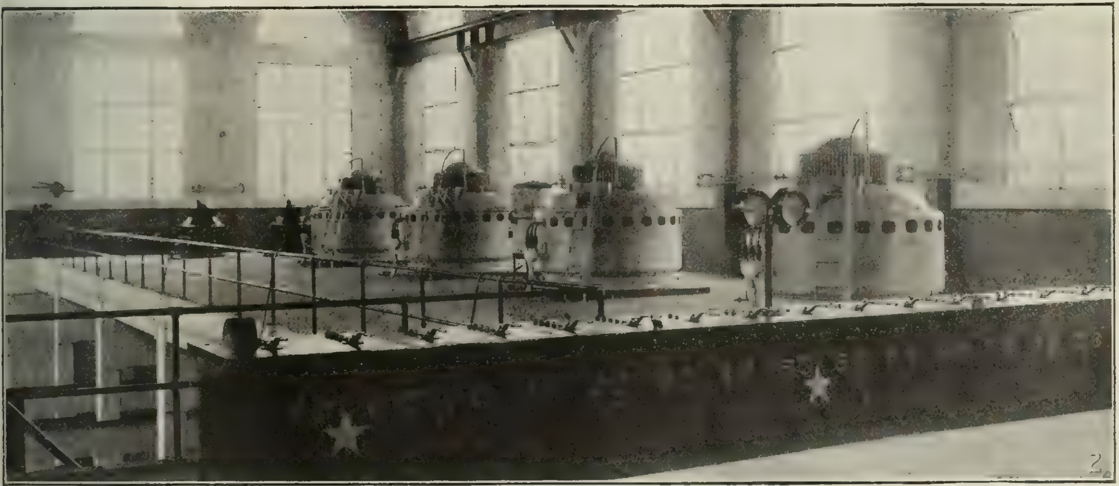
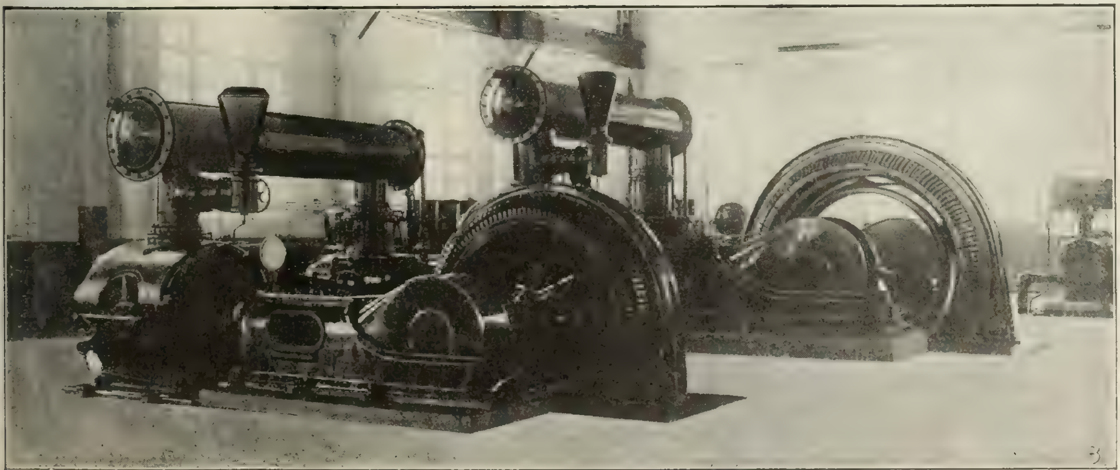
*Naval Constructor; Mechanical Superintendent of Panama Canal Zone.







FIGS. 1 TO 3. EXTERIOR AND INTERIOR VIEWS OF DRY-DOCK PUMPING PLANT AT BALBOA SHOPS, PANAMA CANAL ZONE

Fig. 1—Building containing dry-dock pumps, air compressors and switchboard controlling power to shops. Fig. 2—Interior of building, showing pump motors and control board. Fig. 3—Electrically driven air compressors.

Gatun Lake and is transmitted across the Isthmus at 44,000 volts to the Balboa substation, which is alongside the Balboa shops. In this substation it is stepped down to 2200 volts and delivered at this voltage to small substations located at power centers in the shop area. The headpiece shows the hydro-electric station at Gatun, with one spillway gate open to allow excess water to escape from the lake.

The machinery in the shops is entirely electrically operated, except such machines as hammers, etc., which are not adapted to this type of drive. The current used is three-phase 25-cycle and is delivered to the shops at 2200 volts. The shop motors operate at 220 volts and transformer rooms are located near load centers in the various buildings. The main transformer rooms are placed in the machine and erecting shop, steel storage shed, planing mill and foundry building. The machine and erecting shop has two 300-kv.-a. three-phase power transformers, one 140-kw. single-phase lighting transformer, two 325-kw. motor-generator sets and a 7-panel switchboard. This equipment serves this building only. The transformer equipment in the steel storage shed, planing mill and foundry building is practically the same in each, and consists of two 300-kv.-a. power transformers, one 50, 60 or 125-kw. single-phase lighting transformer, and one three-panel switchboard. The transformers in the planing mill supply that building only, but those in the steel storage shed supply the forge shop and the boiler and shipfitters' shop, and those in the foundry building supply the car shop, galvanizing plant, lumber-storage shed and roundhouse.

All distributing cables are run through the shop tunnel in ducts laid in that wall and are then brought up through manholes in the floor of the buildings. From the manholes cables are run in galvanized iron conduits fastened to the roof trusses or carried on T-iron supports attached to the steelwork of the buildings above the lower chords. Drops are run down the building columns to controllers, panel boxes, etc. On account of limited space, the central switchboards were not arranged to permit control of all power and lighting circuits at the boards; instead of this, junction boxes were installed in each section of the shop, from which the power and lighting circuits for that section are distributed. The transformers are connected to the main substation by a single loop feeder-circuit which has ample capacity to carry the normal shop load on one side, in case of emergency. When the valve- and gate-operating machinery on the north wall of the dry dock is installed, it will be connected to the shop transformers.

Four types of motors were adopted for power drives: Direct-current, commutating-pole, variable-speed motors; slip-ring induction motors; squirrel-cage induction motors, and synchronous motors. Direct-current motors operate on 220-volt current, and alternating current motors on 220-volt three-phase 25-cycle current. The direct-current motors drive lathes, planers, boring machines, milling machines and other tools where a variable tool speed is desired. They have speed ranges from 350 to 1400, 375 to 1125, 375 to 1500, 450 to 1800, and 500 to 1500 r.p.m. The slip-ring, polar-wound rotor inductor motors drive machines that require a high starting torque or that are necessarily reversible; as, for example, bending rolls, low-pressure blowers, the 2-ton Tropenas converter and the transfer table. The squirrel-cage induction motors are used for all group drives and on all group drives and all constant-speed machines. The synchronous motors are used for driving direct-current generators and air compressors and are arranged for operation at 75 per cent. leading power factor for correcting the load factor of the plant. All motors were purchased under specifications calling for specially developed insulation similar to that used on the lock-machinery motors.

Lighting for the shops is obtained from tungsten filament lamps, and general illumination is used throughout. This method was considered preferable to special intensified illumination at each machine or in particular sections of the shop on account of the fact that, as all points received approximately the same amount of light, no change in wiring or the position of lamps is required if the arrangement of machines is changed. Lighting is all on 110-220-volt single-phase circuits. Feeders run from the lighting transformers to panel boxes placed at convenient points throughout the shop, and from these boxes the lights in the individual sections are controlled. Branch circuits are designed for a maximum load of 3000 watts, with a drop of 3 volts.

Burning Fine Anthracite and Bituminous Coal

FUEL conditions during the last two years have been such that the users of coal for power generation have been glad to obtain any grade possible in order to keep their plants in operation. In many instances the practice of mixing what is known as anthracite screenings and bituminous coal has been employed by operators of hand-fired furnaces equipped with natural draft.

Those who have never burned such a mixture might imagine that the difficulties in burning anthracite screenings with a natural draft would be such as to prohibit their use. Experience, however, has shown that they give satisfactory results when properly mixed with bituminous coal. Anthracite coals below buckwheat sizes are valuable for fuel as they contain almost as much carbon as the larger sizes and but little more ash and sulphur. They are, however, difficult to burn with natural draft and should, therefore, be mixed with some soft coal.

When burning a mixture of fine anthracite and bituminous coal, the percentage of screenings will vary, depending upon the grate and the draft. Six or seven parts of anthracite dust to one of bituminous coal makes a fuel that burns well. Increasing the proportion of soft coal makes a quick fire, but produces more smoke. Excellent results can be obtained with 25 to 30 per cent. of small-sized anthracite and 70 to 75 per cent. of soft coal. The mixture will give a hot fire, but will produce some smoke. A mixture of half-and-half fine anthracite and bituminous coal can be successfully burned in a furnace having a good draft.

It is important to thoroughly mix the coal before firing. This is best done by bringing it into the boiler room in a wheelbarrow or by other means, dumping first one load of one kind and then one of the other kind in a pile on the floor and turning the pile over several times somewhat as concrete is mixed. If the mixing is done properly, the firing method need not be changed from that employed in burning soft coal.

Regardless of what mixture is burned, all cracks in the boiler settings should be stopped to prevent air from leaking into the furnace. If a damper regulator is installed, it should be allowed to operate the damper in the smoke connection to the chimney for the control of the steam pressure. Some firemen have the habit of opening the furnace doors to admit cold air over the fire to prevent the boiler from making steam too fast and at the same time allow the damper and ashpit door to remain wide open. The furnace doors should never be left open for any such purpose. If the damper is not in working order, it should be put in shape so that the draft can be controlled by it rather than by means of the ashpit doors. Frequently, the damper regulator is out of order. If this is the case, it should be repaired and connected with the damper so that it will automatically regulate the draft and steam pressure. Arrangements should also be made so that the damper cannot close tight and thus shut off the draft altogether.

As regards the furnace, the grate bars should contain up to ½-in. air space, which is suitable for burning fine anthracite and soft coal. As the anthracite bakes with the soft coal and forms into coarse particles, it will not fall through the grate. To obtain the best results keep the fuel bed level and not too thick; between 5 and 10 in. is considered good practice. It is well to watch for holes in the fire and keep them filled, otherwise an excessive volume of air will pass into the furnace.

In handling a fire the fireman should not disturb the fuel bed too often, as this mixes the ashes with the fuel and causes clinkering. If shaking grates are used, the ashes can be freed from the fire by frequent shaking down, but it is advisable to stop shaking as soon as live coals begin to fall through the grate. After firing, the fuel bed should be left alone and the fire tools should be used as little as possible.

It may be necessary to employ a slice bar if stationary grates are used; and if so, it should be run in under the fire along the grate. Moving the bar back and forth a few times will sift some of the ashes through the grate. If the soft coal is of the coking kind, it may be necessary to slice the fire occasionally so as to break the crust, but care should be taken not to mix the ashes with the burning fuel.

As clinkers and some ash will not pass through the grate, the fires must be cleaned at intervals. The periods will be governed by the proportion of ash in the coal and its character, also by the kind of grate used. A stationary grate will require more frequent cleaning than one of the shaking type. When cleaning a fire, carefully remove all clinkers and ash.

Various methods are used in cleaning fires. One that gives satisfactory results is as follows: Burn down one side of the furnace as much as possible and still keep up the steam pressure during the cleaning period; then wing the live coals to the active side of the grate and with a hoe pull the refuse out of the furnace and into a wheelbarrow. Having cleaned one side, evenly spread some of the live coals from the uncleaned side of the furnace on the clean grate and cover lightly with fresh fuel. When the clean side of the furnace has been built up, the dirty side is burnt down and cleaned in the same manner.

In case a light fire is being carried, it will be necessary to build up one side of the furnace to have enough live coals to cover the grate on the side that has been cleaned. With a boiler that is not being pushed hard, it is possible to burn practically all fuel to ash on the side that is to be cleaned.

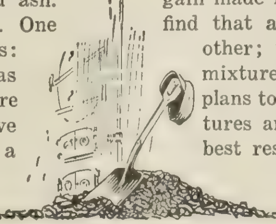
Another method of cleaning fires with dumping grate is as follows: The fire on the side to be cleaned is burnt down and the live coals are brought forward on the front portion of the grate; the rear section is then dumped and the live coals are pushed back on the clean part of the grate; the front portion is next dumped and the live coals are evenly spread and then covered with fresh fuel. After building up the clean side, the other side of the grate is cleaned in like manner. Experience will determine the proper cleaning period for each individual plant.

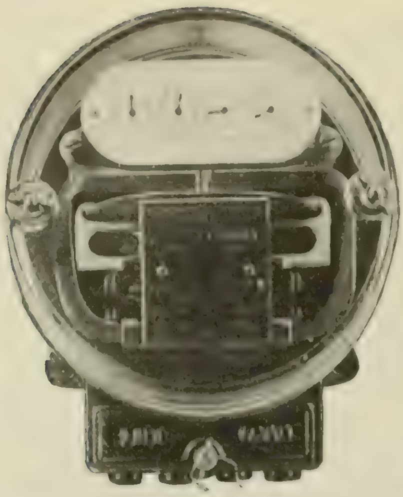
If the grates are of the shaking type and are properly handled, there will be less trouble from clinkering as the ashes can be shaken into the ashpit. Clinkers are nothing more nor less than melted ash, and their formation can be controlled to a large extent by the manner in which the fireman handles his fires. The more excessive the heat in the furnace the greater the probability that clinkers will form. Furnaces that are run at a low rate, and therefore at a comparatively low temperature, are troubled but little with the formation of clinkers.

As has already been said, stirring the fire and mixing the ashes with the live coals produces clinkers because the ashes, being exposed to the intense heat of the burning coal, are fused into a large mass. Naturally, the grade and mixture of the coal will have much to do with the nature and formation of the clinker. Carrying very thick fires coupled with the stirring of the burning fuel bed is a sure way to produce clinkers.

One may ask why a thick fire will cause clinkers to form. This is because a thick fuel bed offers resistance to the passage of the air through it. Without the free passage of air through the fuel bed, the ashes become heated, and upon reaching the melting point, they fuse together and become a solid mass upon cooling. Therefore, clinkers will be greatly reduced if thin, level fires are carried.

In burning a mixture of anthracite and bituminous coal, it is generally not economy to burn anthracite containing more than 20 per cent. of bone and noncombustibles. Furthermore, in many plants the expense of disposing of the ashes would offset the gain made in burning the mixture. One plant may find that a certain mixture is cheaper than another; the second may find that still another mixture is less economical. Each engineer who plans to burn mixed coal should try various mixtures and then stick to the one that gives the best results with his particular equipment.





Testing Single-Phase Watt-Hour Meters Using a Rotating Standard

by

P. B. Findley

While direct current is in general use in smaller plants and for special service such as adjustable-speed motors, the growing plant finds that alternating current, with its economical distribution, is preferable. Hence a knowledge of the construction, maintenance and testing of alternating-current instruments is essential to the well-informed operator. This article considers the single-phase watt-hour meter, used on distributing circuits and the method of testing it, using an indicating wattmeter. A subsequent article will discuss the testing of single-phase watt-hour meters with a rotating standard.

ESSENTIALLY, the single-phase watt-hour meter consists of a light circular aluminum disk *D*, Fig. 1, mounted on a shaft which turns in practically frictionless bearings. At one part of its area this disk comes under the influence of an electromagnet *P* which is connected across the supply line and is known as the voltage or potential element. Another electromagnet *S* is connected in series with the load and is called the current element. As a result there is a turning force upon the disk which is proportional to the power consumed in the circuit. The rotation of the disk is retarded, precisely as in the direct-current meter, by the magnetic "drag" of two permanent magnets whose lines of force are cut by the disk at a part of its area other than that covered by the electromagnets. The speed of rotation is proportional to the rate of power flow (kilowatts) through the meter, and the number of revolutions in any interval of time is proportional to the total power (kilowatt-hours) which has passed. The details of a typical single-phase watt-hour meter can best be seen by reference to the headpiece and Figs. 3 to 5 which are views of a type OA Westinghouse instrument. The headpiece shows the instrument complete; the glass cover and nameplate have been removed in Fig. 3. A side view is given of the meter element in Fig. 4, after it has been removed from its case, and the rear of the meter element is shown in Fig. 5. Arrangement of the various parts is shown in the figures. An aluminum mounting frame *F* serves as a foundation for the meter element. To it are attached the iron punchings *M* which form the magnetic circuit and carry the current coils *C* and voltage coil *P*. Projections from the frame also carry the upper and lower bearings for the moving element. The lower bearing is shown at *B*, Fig. 4; the register mechanism (located at *R*) and dials *I* are also mounted on projections from the frame *F*. The disk *D* is made of a circular sheet of aluminum fastened to its shaft.

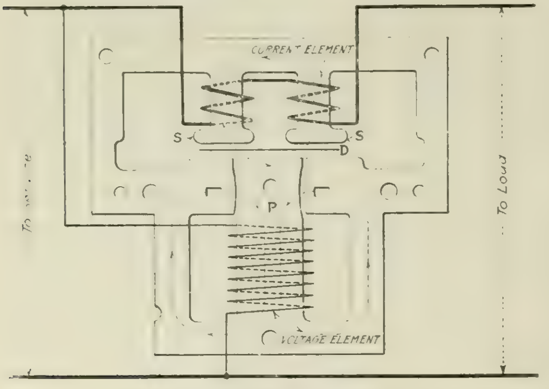


FIG. 1. SCHEMATIC DIAGRAM OF SINGLE-PHASE WATT-HOUR METER

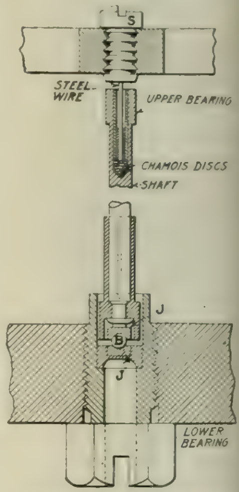


FIG. 2. WATT-HOUR METER BEARINGS

The upper bearing consists of a steel wire, Fig. 2, projecting from a screw *S* which is held in the mounting frame. This wire enters a bushed hole in the upper end of the disk shaft, and at the bottom of the hole are a number of chamois disks moistened with jewelers' oil.

The lower bearing *B*, Fig. 4, whose permanency is vital to the accuracy of the meter, is shown in section in Fig. 2. This bearing consists of two concave jewels *J*, one fixed to the disk shaft, and one in a screw plug in the frame. Between these jewels is a steel ball *B*. This type of bearing is not liable to be affected by long use and vibration. The permanent magnets *A*, Figs. 3 and 4, are fastened to L-shaped punchings, which in turn are secured to the frame by the clamping screws *S*.

The adjustment of a modern watt-hour meter is a job which can be performed easily by a careful man with the tools of an average electrician's kit. Assuming that we have before us an instrument of the types illustrated, the procedure would be as follows:

Disconnect the meter from the circuit after placing jumper wires to carry the current load. This may be done on the type of meter under discussion without making the line dead by first connecting the wires *B* and *C* and then *A* and *D* together by jumpers, as shown in Fig. 6, after which the screws *S* are loosened one at a time and the connections pulled out and taped up as shown in the figure.

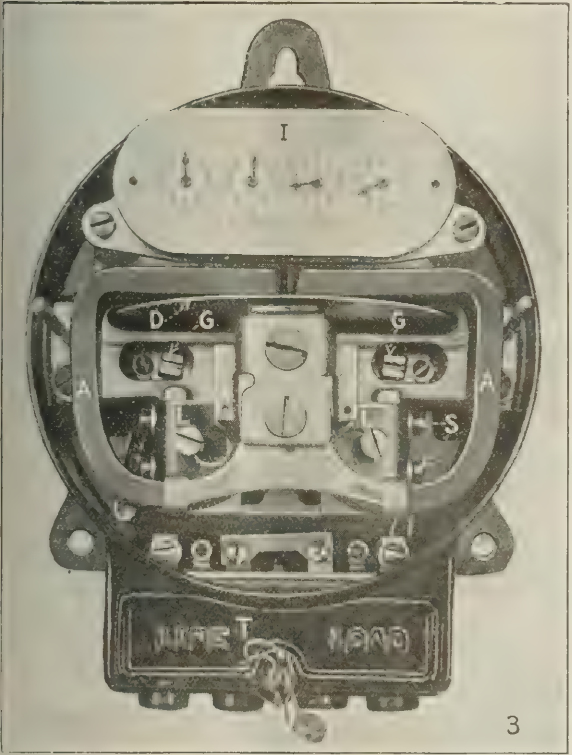
After the meter has been disconnected from the circuit, remove the cover and spin the disk with the finger, noting how long it takes to slow down and stop. Make sure that the disk rotates freely and that it or the shaft has not been bent. This might happen from damage in shipment or from a severe short-circuit.

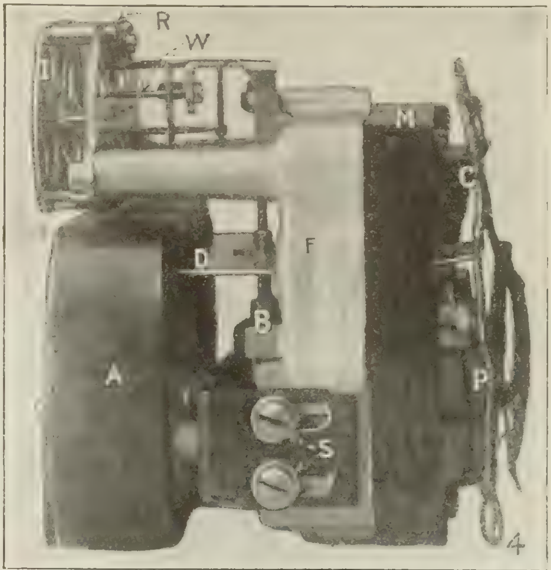
If it seems necessary, remove the register mechanism *R* by taking out the screws *E*. See that the shafts of the indicators and gears have a small amount of longitudinal play and move easily in their bearing; make sure that all are straight and that no oil is on the worm or its gear. The worm and gear is shown located at *W*, Fig. 4. If the disk does not turn freely after the indicating mechanism has been removed, the meter should be repaired. This is not a difficult task in a properly equipped shop, but detailed instructions should be secured from the manufacturer of the meter.

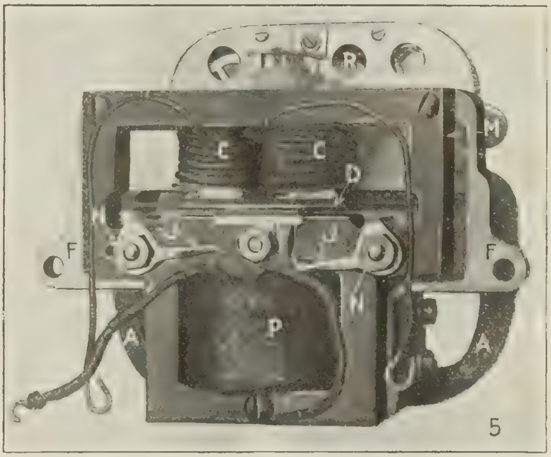
Sometimes it will be found that the shaft rattles in its bearings when the meter is alive. This is due to the shaft having the same natural frequency of vibration as the frequency of the circuit. Usually, the trouble can be corrected by putting in a new top bearing.

The inside of the meter and cover should be thoroughly cleaned before the cover is replaced.

After inspection, the meter is put on full voltage with no load on the current coils. This can be done by connecting up the two line terminals as shown in Fig. 7. The "light load" adjustment is moved by turning the square-head screws *G*, Fig. 3, until the disk does not "creep" in either direction. Practically, this test is made by giving the disk a very gentle push, first in one direction, then in the other, with the finger. It should not continue to rotate in either case.







FIGS. 3 TO 5. ASSEMBLY VIEWS OF SINGLE-PHASE WATT-HOUR METER

The light-load compensator in the meter under consideration consists of two metallic loops which pass through the air gaps in the voltage coil's magnetic circuit. They can be seen at *J* in Fig. 5, being clamped under the large hexagonal nuts *N* to right and left of the polepiece of the voltage coils. By turning with a screwdriver the large square-head screws *G*, Fig. 3, these loops are made to move in the air gaps. If the meter creeps forward or is fast on light load, both screws are turned clockwise, and if the meter creeps backward or is slow on light load, both screws are turned counterclockwise. Before doing this, the round-head clamping screws should be slightly loosened and afterward tightened.

It will generally be found that if the meter does not creep, it will be correct on light load; that is, 10 per cent. full load. However, the latter condition is the one for which adjustment must ultimately be made.

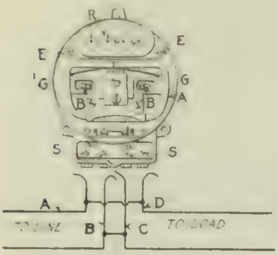


FIG. 6

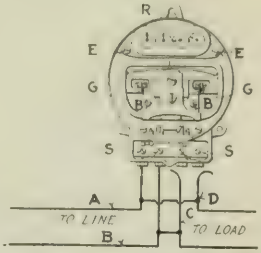


FIG. 7

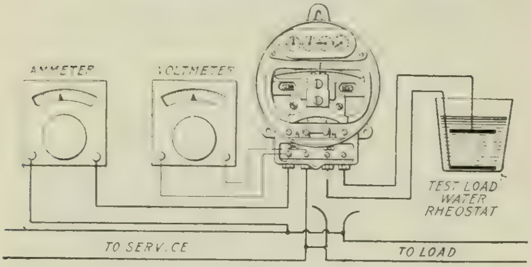


FIG. 8

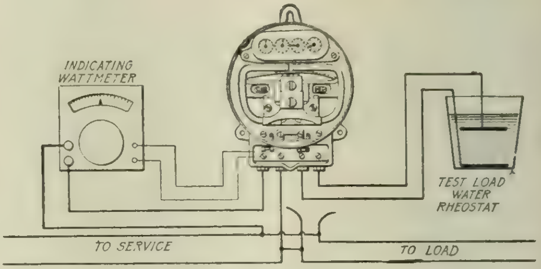


FIG. 9

FIGS. 6 TO 9. CONNECTION DIAGRAMS FOR TESTING SINGLE-PHASE WATT-HOUR METERS

The full-load adjustment is made by changing the position and hence the damping effect of the permanent magnets *A*. By moving them in toward the shaft, their effect is decreased and the meter will run faster; by moving them out, the meter will run slower. Each manufacturer provides differently for this, but inspection will show how it should be done in any given meter. On the meter shown, the full-load clamping screws *S*, Fig. 3, are loosened slightly, and each magnet is moved in or out by its adjusting screw *L*. The screws *L* have a shoulder below the plate through which they pass that pushes out this plate and the attached magnet; the screw-head pushes them in. After final adjustment the clamping screws are tightened. About one-half the change in adjustment should be made by motion of each magnet.

It may be desired to check the full-load adjustment at low power factor when the load is one which operates much of the time at low power factor. Such a load would be one of induction motors running light or of unloaded transformers. This test is not generally made in the field by central stations, but only in the shop. Many watt-hour meters are constructed and set at the factory to be accurate at unity and at 70 per cent. power factor and no adjustment is provided. This is true of the meter illustrated.

The lag adjustment, when furnished, consists of a small coil of copper wire wound around the voltage-coil polepiece. This coil is short-circuited through leads of variable length, which are used to control the resistance of the coil. Variation to secure accuracy at low power factor usually changes the calibration at unity power factor and hence a check test should be made at full load and unity power factor, with adjustment if necessary.

Any alternating-current instrument or combination of instruments which measure electric power and time can be used for calibrating alternating-current watt-hour meters. The simplest combination is a voltmeter, ammeter and stop watch, used on a circuit of unity power factor; that is, a resistance load as indicated in Fig. 8. The resistance may be either a water rheostat or a bank of incandescent lamps. As there are three instruments to be observed, and as unity power factor is the exception in alternating-current work, this method is not always practical.

A satisfactory arrangement is an indicating wattmeter and a stop watch, particularly when an accurate wattmeter is already part of the electrical equipment. A switchboard instrument is not considered sufficiently accurate for this purpose. In making the test with a wattmeter, the potential coil of the wattmeter is connected across the potential coil of the watt-hour meter under test, and the current coil in series with that of the watt-hour meter, as in Fig. 9.

When the desired load on the watt-hour meter has been secured, the disk will turn in the direction marked by the manufacturer. While the helper holds the power indication of the wattmeter constant by varying the rheostat, the tester times a certain number of revolutions of the watt-hour meter disk. The time should be between 30 and 60 sec.; since a stop watch is accurate to only 0.2 sec., the longer the time the less the percentage error in reading.

The formula for the error of the watt-hour meter is

$$E = \frac{3600 K_h N \times 100}{PT} - 100$$

where

E = Per cent. error;

3600 = Number of seconds in an hour;

K_h = Watt-hour constant of meter = watt-hours for one revolution of disk;

N = Number of revolutions in T seconds;

P = Watts flowing through meter.

The watt-hour constant K_h depends on the make, type and capacity of the meter. It is found on a Westinghouse meter on the inside of terminal chamber cover, where are marked revolutions r of the moving element for a given number of kilowatt-hours P from which

$$K_h = \frac{P}{r}.$$

For a concrete example assume that we have on test the meter shown in Fig. 3. This instrument is rated at 60 cycles, 100 volts, 5 amperes for two-wire service. On the inside of the terminal chamber cover T, Fig 3, we find, one revolution of moving element = 0.333 kw.-hr.; that is, K_h = 0.333, or 1/3. Our first test, at no load, shows that the meter creeps slowly forward. By moving the light-load adjustments we correct this, and then take a set of three readings at 50 watts, for the time of three revolutions. The average of three readings is 71.3 sec. Substituting in the formula, we have

$$E = \frac{3600 \times 0.333 \times 3 \times 100}{50 \times 71.3} - 100 = 0.98, \text{ or about}$$

1 per cent. fast, which is near enough.

The load is now set at 500 watts, and the time of 20 revolutions taken. The average of three readings assume to be 46.1 sec., which gives

$$E = \frac{3600 \times 0.333 \times 20 \times 100}{500 \times 46.1} - 100 = 4.1, \text{ or 4 per}$$

cent. fast; therefore, we move the magnets outward a small amount and take another set of readings. This time assume we get 47.6 sec. for 20 rev. and E = 0.84, or less than 1. Another very small movement of the magnet would set the meter as nearly correct as the accuracy of our observations would justify attempting.

There are several points to be noted in the foregoing tests. The value for P is true watts flowing. The wattmeter reading will usually be different from this, its error being given on a curve accompanying it, which is corrected each time it is calibrated. Before making the test, the wattmeter potential circuit is opened, and the pointer, if not on zero, is set so. The position of the pointer for the desired load is then obtained by adding to or subtracting from the scale reading the amount of correction shown on the calibration curve, and the load is regulated to hold the pointer at that mark, regardless of voltage fluctuations. This may be done by a carbon-block or slide-wire resistance in parallel with the "fixed" part of the load.

By solving the foregoing formula for T, putting E = 0, we find that if the meter is exactly right (zero error), for a load P = 500 watts, and time T for 20 revolutions

$$T = \frac{3600 K_h N}{P} = \frac{3600 \times 0.333 \times 20}{500} = 48 \textit{ sec.}$$

For the preliminary rough tests while setting the magnets, we can then simply try to get T as near 48 sec. as possible and work out the actual error only when satisfied that we can come no closer.

The accuracy of this method depends on how closely the wattmeter indication is held constant. This depends on the steadiness of the voltage and on the proficiency of the helper in manipulating the rheostat. Sometimes an isolated generator or a lightly loaded one can be secured. In general, the difficulties of the foregoing method have caused it to be superseded by a rotating standard. The use of a rotating standard for testing alternating-current wattmeters will be described in a subsequent article.

Wastes Due to Leaky Boiler Settings

By HARVEY G. HAYS

There are in most steam plants wastes that can be reduced to some extent. One source of loss is air leakage through the boiler settings, which can be practically prevented if the engineer will carry out the suggestions made in this article.

ERECTING a boiler is similar to erecting a steel-framed building. The boilermaker sets up his iron supports and hangs the drums and tubes with the necessary piping connections. When this is done, the brickmason comes and the boiler is inclosed. The purpose of this brickwork is to form the inclosing ducts for the heated gases while the boilers are absorbing the heat. It is the office of the chimney to furnish the draft which causes the air to flow into the furnace through the fuel bed and through the passages in the boiler where the heat generated by the combustion of the fuel is absorbed by the water and converted into energy.

In order to properly perform its function, two things are essential in the brick setting: It must be tight so that the air will be forced through the fuel bed and cause it to come into contact with the combustibles. It must also force the heated gases to travel in the paths laid out by the boilermakers so that as much of the heat as possible may be absorbed by the water within or around the tubes.

When a boiler is in service, the gases in the boiler passes and inside the chimney are heated. They are accordingly lighter than the air surrounding the boiler setting and the chimney. The tendency is therefore for the heavier cold air to push into the boiler setting through every opening, crack, crevice or pore in the brickwork, as well as through the grates and up through the fuel bed, where it was intended that the draft should cause it to flow. Regulation of the flow of the air through the fuel bed, important as it is, will not be mentioned here but only the excess air which gets in through leaks or pores in the brickwork or is not properly "routed" in the boiler passages.

EXPANSION AND CONTRACTION

Every substance expands and contracts under changes in temperature. In each 180 deg. iron changes one part in 800 approximately, while firebrick changes only one part in 2000. The result is, of course, that when the boiler is fired up, the ironwork expands more than the brickwork, which is slightly moved when the iron expands. When the boiler cools and the ironwork shrinks, the brickwork stays where it was pushed, and the process is repeated when the boiler is fired again. Cracks are developed in this manner, and inasmuch as these conditions continue as long as the boilers are in service, it is necessary that the engineer or whoever is in charge be continually on the watch to keep the settings tight.

Few engineers realize the loss for which a leaky setting may be responsible. Combustion engineers place the average loss at 10 per cent. and report finding it as high as 20 per cent. in extreme cases. Whatever the loss, it is preventable and is inexcusable, for the air which finds its way into the boiler passages through the brickwork does no good as it does not promote combustion, but serves to absorb the heat.

Most engineers will tell you that their boiler settings are tight, in good shape or fair. Few will admit that they need attention. Occasionally one will own up that he knows they are "rotten," but amplifies by stating that next spring they are going to reset the boilers and there is no use doing anything to them now.

BOILER-SETTING LEAKS MAY BE READILY LOCATED

It is easy to locate the boiler-setting leaks if they are gone over with a lighted candle and every crack tested that looks suspicious. In most cases the flame of the candle will be drawn into the crack. Sometimes the candle will be snuffed out. A leak of that caliber is responsible for an appreciable waste of fuel. Another "eye-opener" for the engineer is to have him throw a scoopful of green coal on the fire and close the boiler damper tightly. By watching where the smoke comes out one can be assured that wherever smoke issues air enters, because the conditions have been reversed and the pressure is inside instead of outside the setting.

Another source of leakage commonly overlooked is in the division walls between boilers set in batteries. These walls are carelessly laid up many times. It is difficult to properly inspect them, and on the theory that "what a man doesn't know doesn't hurt him," the average engineer usually passes them by. If the boiler happens to be "down," however, the leak is just as serious as if the leaks were in an outside wall. The live boiler will draw cold air from the dead one, and fuel will be wasted.

LEAKS WHERE IRON AND BRICKWORK MEET

In looking for leaks, examine every point where iron and brickwork meet. See that the fronts are tight and not warped and sprung away from the brick backing, and that the clean-out doors fit tightly. If the boiler is of the water-tube type see that the headers are properly packed and be sure that the doors covering them are closed tightly. If the headers have hollow stay-bolts, make sure that these are plugged and kept so. Examine the "dead plate" in the fire-door and see that there is no passage to the ashpit below. Carefully examine every suspicious crack and test it with the flame. Make sure that all the air drawn into the boiler is drawn in through the fire bed. When sure that all leaks have been located, it would pay to have someone test the flue gases with a gas analyzer if the plant is not supplied with the apparatus and make sure that nothing has been overlooked. Keep after the leaks until the gas analyzer shows the same percentage at the front passages as at the back passages, and then it is reasonably sure that the settings are tight.

Do not conclude that because a crack looks small there is no leakage. Indeed, there may be an appreciable infiltration and no crack at all because dry brickwork is porous. Throw a brick into a pail of water and see how quickly it absorbs the moisture. The only safe way is to cover the boiler settings and be sure to flush up to all ironwork and calk all large cracks before applying the coating. Whitewash with glue dissolved in it makes a good covering and smokestack or roofing paint is sometimes used; coal tar answers the purpose temporarily. There are a number of special coverings made for this particular purpose, composed of asphalt, asbestos and certain drying oils and so mixed as to retain their elasticity for a longer time than the cheaper substitutes mentioned. Anything that will seal the pores and stop the cracks will answer the purpose.

ASBESTOS PLASTER THE BEST COVERING

If the best kind of a job is desired, apply a good quality of asbestos plaster over the setting and put it on at least two inches thick. Cover this with a layer of canvas and give the canvas a good coating of paint. The boiler will then be insulated as well as sealed and will increase the efficiency by retaining most of the heat.

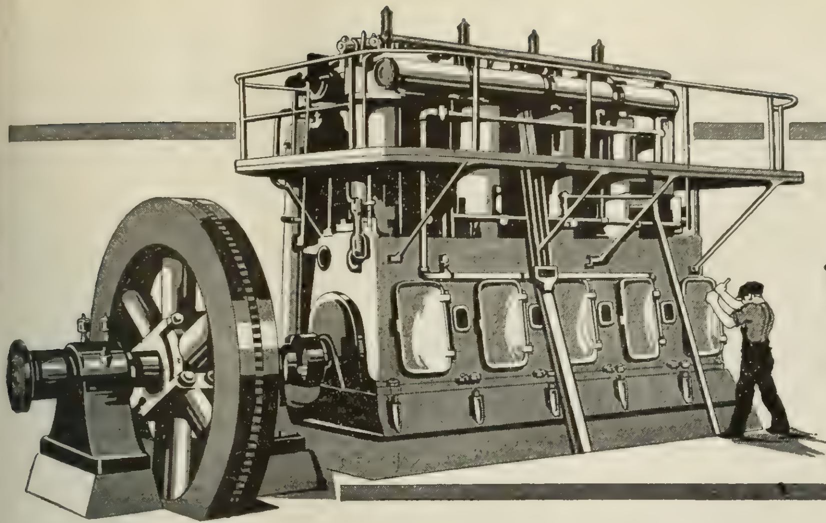
If the boiler is of the ordinary return-tubular type and measures have been taken as suggested, that is about all that can be done in cutting out wastes from leakage. With a water-tube boiler, however, it will be necessary to inspect the baffles to make sure that the heated gases are compelled to travel in the paths laid out for them. The baffle tiles are made of fire clay and are hung on the tubes in a water-tube boiler for the purpose of lengthening the path of the gases and making them come into contact with as large a tube area as possible. This gives the water in the tubes an opportunity to absorb as much heat as possible and reduces the temperature of the escaping stack gases.

INSPECTION OF BAFFLES

If the baffle tile are broken or burned away, the hot gases will not travel by the long path laid out for them, but will take the shortest route for the chimney and may miss more than half the heating surfaces. The result is that the heat is not extracted from the gases, but passes up the chimney and fuel is wasted. A flue-gas thermometer is a handy instrument for detecting these conditions. A better way is not to allow them to occur. This will mean that somebody will have to crawl into the boiler and carefully inspect the baffling whenever the boiler is down, and that somebody sees that a supply of tile is kept on hand with which to make repairs.

Sometimes, but not always, the engineer is responsible for the conditions referred to in the foregoing. Often the engineer is required to do so many things around the plant that he does not find time to look after the boiler settings. He may know it should be done and intend to do it when he has the time. Ordinarily, he does not appreciate how expensive his delay is.

The shortage of coal in Denmark has led to high prices being paid to people to work in the peat bogs. It is no unusual sight to see students, military officers and others digging industriously in such places.



Talks on DIESEL Engines

by L. H. Morrison

IV—The chief describes various types of connecting-rods and the methods used in adjusting them. He also explains how piston pins should be ground and lapped.

WHEN the men came together again for their discussion of Diesel-engine troubles, Kelly was quiet and subdued. This mood was so unusual that J. R. twitted him about it. As he had expected, he got a rise.

"It begins to look as though I'd have to rebuild the whole engine," Kelly complained. "It has an old-style connecting-rod like this"—he opened a dogeared instruction book and pointed to a sketch like that shown in Fig. 1. "The manager saw one somewhere with a wedge adjustment on the piston-pin end, and now he wants me to change this one. It's a job I can't do; and what's more," he added, "I don't believe the machine shop can, either."

"It was bound to come sooner or later," Egan consoled. "But begin early—sit down on him."

Kelly looked relieved, and Egan went on:

"As I recall, that type of engine was originally built with the type of rod shown in Fig. 1. The big end is like that generally used at the present time, but the little end or piston end has a modified marine box. In later engines of American make the piston end was fitted with a wedge adjustment along the lines of Fig. 2.

"In making adjustments I'll agree that the wedge is handy, since the piston and rod need not be removed from the engine. In fact, it is too easy to adjust, for often the engineer will draw up on the bolts when it is the big end that is knocking. This feature could be overlooked if there wasn't a strong tendency for the wedge bolt to break. I know of a number giving way under heavy load. Of course the wedge is common practice on steam engines, but the manner of application is different. In a steam engine the wedge is vertical, and since it can be longer, the angle of the wedge can be less. In the oil engine the wedge can't be placed at right angles to the pin axis, because there wouldn't be room for a wrench inside the piston. Consequently the wedge is placed parallel to the pin. It must be very short, being only the width of the flat rod end, and the wedge angle is steep to give a considerable raising effect for a small lengthwise movement of the wedge."

"What makes the wedge bolt break?" one of the men asked. "I got the idea there wasn't any explosion in a Diesel engine."

"That's right," answered J. R. "The Diesel is not an explosion engine; but still there's a blow given to the piston at the beginning of the oil injection. This blow is taken by the piston pin and the wedge gets the full effect of it. Since the wedge angle is steep, a large part of the blow is absorbed by the wedge bolt. These repeated shocks cause crystallization of the bolt and finally it fails."

"I don't agree with you that the wedge type is easy to adjust," Kelly broke in. "It's darn hard to put in the shim between the two brasses."

"You are about right," confessed Egan. "However, you'll find a good many men who don't insist on taking up the play by changing the shims. Some use the wedge exclusively; but it's these fellows who are always breaking wedge bolts.

"A new design of the wedge type, like this"—Egan opened a catalog of a horizontal engine and pointed to an illustration similar to that in Fig. 3—"does away with shims by using adjusting screws to take up the wear, the wedge serving as a support."

"I think the hardest part is to judge just how tight to draw up on the wedge," offered Woods, the new oiler.

"That is one thing that an operator can learn only by experience," replied the chief. "Each engine will require a different amount of play. As a rule I believe the wedge should be drawn up tight and then slacked off about an eighth turn of the

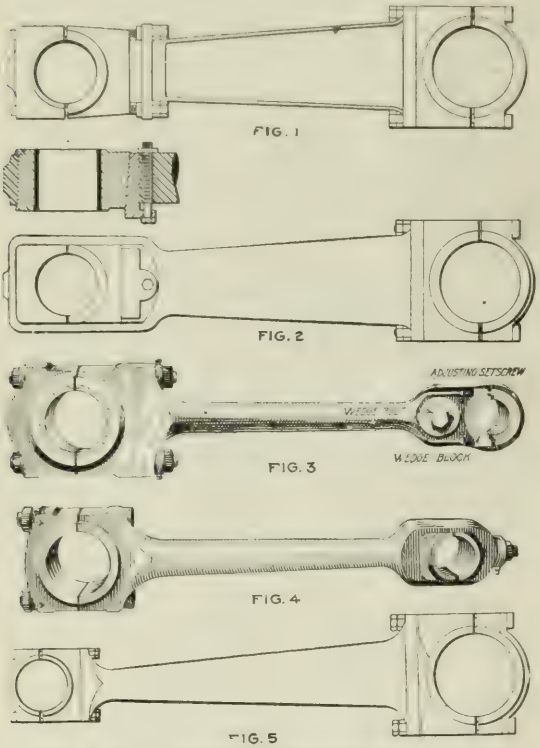
The next article takes up the discussion of the relative advantages of A frames and box frames, with some side remarks by Egan on cooling hot bearings

wedge bolt. There will be enough in the shims to allow this."

"That applies to wedges; but how about the other types without wedges?"

"In the other types the brasses should be allowed enough play to enable a man to swing the connecting-rod with a small effort. In adjusting rods like those shown in Figs. 4 and 5, drive out the pin, so that the rod can be withdrawn from the piston. Then fit the pin to the rod by removing the correct amount of shims. If a setscrew is used, as in Fig. 4, draw this down snug. The piston, rod and pin are then assembled, and the connecting-rod swung by hand to see if the brasses are too tight. Since all this requires removal from the cylinder, it takes some time, but you know you have the adjustments correct.

"When you turn to the big ends, you will find every up-to-date manufacturer using the marine type with the babbitt cast directly onto the steel housing. If you ever have to rebabbitt the big end, you'll find it as easy as running a main bearing, and the procedure the same, including heating the steel housing before running the babbitt. Another thing worth remembering is to use plenty of shims so that the box can be taken up a good deal before it needs to be replaced."



FIGS. 1 TO 5. FORMS OF CONNECTING-ROD ENDS

"What about the clearance between the bearing faces and the crank web?" inquired Kelly.

"Like all adjustments, this varies in different engines; but around seven-thousandths on each face is about right."

"In adjusting one of the big ends on No. 1 engine last Sunday, I calipered the diameter, and it seemed that the bearing was worn more on one end than on the other. Why is that?" queried the oiler who was working in Kelly's place.

"You'd best ask a wiser head than mine about that," laughed the chief. "I do know that in almost all vertical Diesel engines the wear on the crankbox is greater on one end than on the other. In fact, frequently one end will show a remarkable wear immediately after being adjusted. More often the ends wear faster than the center, causing the bearing to become bell-mouthed. While we don't know the reason, we do know it exists and should guard against the consequences. In engines having seen considerable service, the neglect of this feature may cause extensive cylinder wear on one side and require the cylinder to be rebored much sooner than would otherwise be the case.

"While we are discussing big ends, I might call your attention to the fact that you should caliper the crankpins at least every six months. There is always a likelihood of the pins wearing flat. To remedy this the engineer must file the pin and then finish up by doing a careful job of lapping.

"Another detail you should attend to each time the pin is calipered is to examine for surface fracture. The majority of broken crankshafts have failed at the junction of the pin and the crank web. So remember to wipe the pin and web perfectly clean and examine the entire circumference with a magnifying glass."

"Mr. Egan, why are the piston pins and the bosses on the piston ground to a taper seat? On the hot-ball engine I ran, the pin wat straight and the bosses were only bored." It was Woods who put the question.

"Woods, that feature is one of the many that differentiate Diesel-engine workmanship from that found on hot-ball engines. As to why the taper seat is used, let us recall what we discussed about the hammer blows breaking wedge bolts. If there is any play between the pin and its seats in the two bosses, the shock will cause the pin to wear an elliptical seat in the bosses. If a straight pin was used, it would be impossible to get an absolutely tight fit in the bosses; but by using a taper on each end the pin and the seats can be ground together, and if any wear does occur, it can be taken up by regrinding. In fact, regrinding can be done so perfectly that it is impossible to remove the pin without using a sledge and copper mallet.

"To grind the pin without allowing it to stick, lay the piston on two 6 x 6-in. timbers, as shown in Fig. 6, with the pin in a vertical position. Put a spring under the lower end of the pin, strong enough to lift it from its seat, yet allowing the operator to push it back into contact by pressure on the pin wrench. Coat each of the taper surfaces of the pin with emery paste, put the pin into the piston, press down hard enough on the pin to cause it to seat, and rotate it, making a little more than a quarter of a revolution. Gradually revolve the pin, at the same time rotating it back and forth. This will cause every point on a circle of contact to be ground to a perfect seat. A lot of engineers grind the pin by giving it a quarter- or half-revolution only, never completely revolving it. This tends to make the contact surfaces out of round.

"After rotating back and forth a few minutes, release the pressure, move the pin around a little, apply more paste, push the pin back into contact and grind away some more. All the requirements for securing a good taper fit are patience, a good emery paste and honest effort."

"What grade of emery paste do you recommend?"

"For finishing the job always use the finest of emery paste. Emery flour mixed with good machine oil is very satisfactory."

"That's the very kind I was using last month when the chief kicked so hard," one of the day oilers whispered in a loud aside to Kelly.

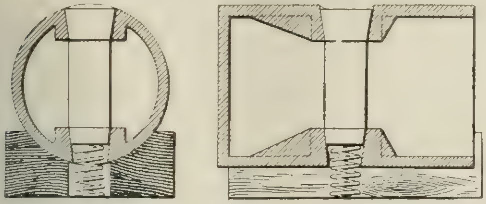


FIG. 6

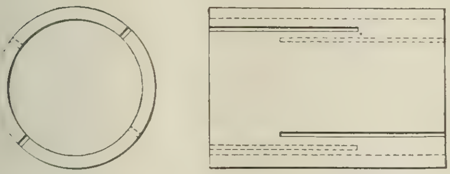


FIG. 7

FIGS. 6 AND 7. GRINDING AND LAPPING PISTON PIN
Fig. 6—Rig for grinding pin. Fig. 7—Sleeve for lapping pin

Egan's sharp ears caught the remark.

"Johnson evidently failed to note I said 'for finishing,'" said the chief. "For starting the job, the condition of the pin will determine the grade of grinding paste. If the pin and bosses are badly out of shape, the quickest and best way is to rough out the seats with coarse emery paste. This will take out all the lines and bring the surfaces to their correct shape. Then the finishing job requires the finer paste.

"Sometimes the piston pin becomes flattened. To bring it back to its original shape, first caliper it very carefully to find out where it is out of true. Then lap the pin, using a lot of patience with the job. This will reduce the pin diameter, so be sure to take out the pin brasses and scrape them to a new fit. There are cases where the pin is so flat that it can't be trued up by any amount of lapping, and the only thing that can be done is to anneal the pin and true it up on a lathe. Then harden it, taking care that, after quenching it in water, the temper is drawn back enough to prevent the pin from being brittle. The pin is now ready for grinding. In case there is no machine shop handy that has a regular grinding machine, the best method is to use one of these motor-driven grinders which can be mounted on the lathe toolpost. A good mechanic should be able to grind within one-thousandth of an inch of the desired pin diameter. This is a job that an ordinary operator should not undertake, and usually the average engineer had best purchase a new pin from the manufacturer."

"Chief," Woods ventured, "you say 'lap' the pin. Now, that's a word I've heard used a lot, but nobody ever explained what it meant."

"Lapping may be defined as rubbing to a perfect surface by means of fine emery paste," said Egan. "For an ordinary job of lapping, a good method would be to apply the emery paste to a cloth and rub the pin briskly, stretching the cloth so that it covers at least half the circumference of the pin. An ideal way is to make a brass collar like that in Fig. 7, as near the pin diameter as possible, and slot it at four points. By placing this on the pin with a small amount of emery paste, it can be rotated and will finish the pin in a most approved manner."

Woods spoke up once more.

"You have been talking about pins with taper ends. Now, I have a number of catalogs of Diesel engines, and it seems to me that a lot of 'em use straight pins."

"Maybe I did give you fellows the idea that all Diesel builders use taper piston pins. Of course, that isn't a fact. Probably as many use the straight pin as use the taper pin. But the tendency now is to use the taper pin, and that is why I thought it best to make mention of that type."

Shunt and Series Windings Opposed

By E. C. Parham

Opposition of the shunt and series windings of a compound-wound generator is not likely to be suspected until an attempt is made to put on a load. If the shunt winding is connected across the brushes, as in Fig. 1, the no-load series-field current will be zero. If the shunt winding is so connected as to include the series winding in its circuit, as in Fig. 2, the no-load series-field current will be the shunt-field current, which will be too small to have appreciable effect through the few series turns. On applying a load, however, the increasing value of the series-field current increases the opposing series-field effect and a load much less than full load will be the limit to which the current can be increased and maintain the voltage at normal value by adjusting the shunt-field rheostat.

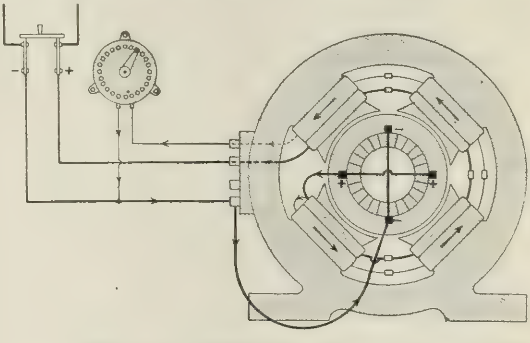


FIG. 1. COMPOUND GENERATOR WITH SHUNT WINDING CONNECTED ACROSS THE ARMATURE

Complaint was made that the voltage regulator of an exciter could not maintain the alternator's voltage, because the exciter was too small. An inspector found the field regulator out of order. However, the putting of the regulator into shape did not improve the voltage conditions. The operator said that the trouble could not be in the exciter because he had just temporarily removed it from motor duty which it had been satisfactorily performing for several years. This statement proved to be a clue to the trouble. On short-circuiting the series-field winding of the exciter, regulation became much better, and on reversing the series-field connections of the exciter, regulation became normal.

The compound-wound motor was being applied to generator duty that called for the same direction of rotation as when used as a motor, and the series-field connections should have been reversed at the time of making the change, but they had not been; therefore the shunt-field windings and series-field windings were opposing each other. The best that the regulator could do was to hold the shunt-field rheostat short-circuited, thereby giving maximum value of shunt-field current. Even this maximum value was not sufficient to maintain the voltage of the alternator.

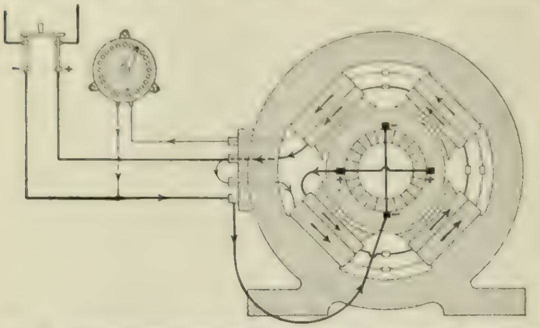


FIG. 2. COMPOUND GENERATOR WITH SHUNT WINDING CONNECTED IN SERIES WITH SERIES WINDING

Comparison of Oil and Coal as Fuel

Basing general statements on results obtained in a few isolated cases is a foolish policy and often leads to large mistakes. For example, it would be incorrect—in many instances even absurd—to say that oil fuel is preferable to coal on the grounds of smaller cost of steam produced. Such a statement is true only under certain definite conditions and those qualifying conditions should be included.

As an illustration, consider the fuel situation in southern California. There are no near-by coal fields, and the cost of coal is therefore very high. On the other hand, there is a plentiful local supply of petroleum, and as a result oil fuel is commonly used under steam boilers in that and surrounding regions. Under the circumstances it is the cheaper and is therefore the logical fuel to be used.

In the East, conditions are reversed. Fuel oil must be transported considerable distances, whereas coal fields are well distributed over the entire territory. The result is that coal forms the almost universal fuel, oil being burned only in a few localities to which it may be carried cheaply by steamers.

The whole question of the relative values of these two kinds of fuel for steam generation narrows down to the cost of producing 1000 lb. of steam from and at 212 deg. F. with each. The solution in any particular instance should take into account not only the cost of the fuel delivered in the boiler room, but also the labor cost and the heating value of each fuel.

One of the advantages of using oil fuel is that the number of firemen may be reduced, but this factor becomes appreciable only in the larger plants; for obviously, the small plant containing one or two boilers must have a fireman, no matter whether coal or oil is used. There is the further advantage that oil leaves no ash and consequently the problem of ash disposal does not enter. Because of the better mixture of air and oil spray, the oil-fired boiler may be operated at an efficiency from 5 to 15 per cent. greater than that of the average coal-fired boiler.

As against these advantages it must be remembered that the supply of oil is limited and that any concerted move to replace coal with oil would at once run the price of oil up to a prohibitive figure, because the demand would far exceed the supply.

It is not possible to state, offhand, which of the two fuels is the more economical under certain conditions. The proper thing to do is to calculate the relative costs, based on the heat values of the fuels to be compared.

At present quotations, fuel oil costs from 7 to 15c. a gallon, an average price being 10c. Suppose, for the sake of argument, that the oil weighs 7.5 lb. per gallon, that its heating value is 19,200 B.t.u. per lb. and that the boiler efficiency is 75 per cent. The boiler would utilize $19,200 \times 0.75 = 14,400$ B.t.u. for each pound of oil used, which would account for the evaporation of $14,400 \div 970.4 = 14.84$ lb. of water from and at 212 deg. F. To evaporate 1000 lb. of water from and at 212 deg. F. would require $1000 \div 14.84 = 67.4$ lb. of oil; and as the oil weighs 7.5 lb. per gallon, it would require $67.4 \div 7.5 = 9$ gal., which would cost 90c. In other words, it would cost 90c. to evaporate 1000 lb. of water with oil under the assumed conditions of cost, heating value and efficiency.

Suppose that the coal to be used has a heating value of 14,000 B.t.u. per lb. and the boiler efficiency is only 60 per cent. The boiler will then absorb $14,000 \times 0.60 = 8400$ B.t.u. for each pound of coal burned, and will have an evaporation of $8400 \div 970.4 = 8.66$ lb. of water from and at 212 deg. F. To evaporate 1000 lb. there will be needed $1000 \div 8.66 = 115.5$ lb. of coal of the grade specified.

Now, if the oil and the coal were of equal economic value under the assumed conditions, the 115.5 lb. of coal would be worth 90c., which corresponds to $90 \div 115.5 = 0.78$c. per lb., or $15.60 per ton of 2000 lb. Stating this in another way, it may be said that if the given coal costs $15.60 a ton it will give just as good evaporative results as fuel oil at 10c. a gallon; and from this it follows that oil would not prove the more economical unless the cost of coal was greater than $15.60 a ton. From such figures as these it will be seen that oil has no economical advantage over coal except under the most favorable circumstances.

Natural gas carries with it the vapors of gasoline and other hydrocarbons that may be recovered in liquid form by the absorption process. Briefly, this process consists in spraying an absorbing oil downward through a tower and forcing the natural gas upward through the spray. The oil absorbs the gasoline from the gas, which passes out and can be used for fuel. The gasoline is then driven off from the absorbing oil by steam heating and the vapors are condensed, producing liquid gasoline. The absorbing oil, freed of the gasoline, is cleaned and used again as an absorbent.

Some Tests with Flow Meters*

By JOSEPH A. MAGUIRE

In order to increase plant efficiency actual facts must be known. The flow meter furnishes means for readily obtaining the actual consumption or output of a steam generating or consuming apparatus. The tests here described resulted in the elimination of wastes that were unsuspected.

PRESENT world conditions, necessitating conservation of all resources, have brought to a deserved prominence many pieces of apparatus heretofore incorrectly looked upon as luxuries. Some years ago the flow meter was in this class, but of late power plants in all industries have been straining to their utmost in an endeavor to raise efficiencies and, consequently, the real value of this device has been gradually realized.

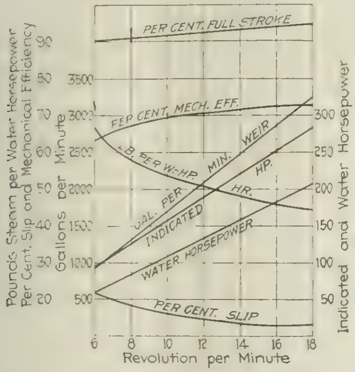


FIG. 1. CHARACTERISTIC CURVE OF DUPLEX COMPOUND CONDENSING PUMP

Steam end, 19 x 36 x 36 in.; water end, 21 x 36 in.; head, 248 ft.; suction, 10 ft.; steam pressure, 125-140 lb.; Scranton jet condenser vacuum, 22-24 in. Steam curve includes losses in 1460 ft. of 8-in. main and 68 ft. of 5-in. main.

Considerable prominence has been given to the use of the flow meter in boiler rooms of manufacturing industries, central stations, etc., but its application to mine power plants is practically an untouched subject. The present article is an account of operations in this field.

A short time ago a number of collieries operating 36 boiler and power plants were thoroughly investigated by their owners and engineers. These men had foreseen the coming coal shortage and were preparing to meet it not only through increased production, but by conservation in their own plants. Flow meters were installed as a means of obtaining the required information.

The testing equipment at first consisted of four flow meters, the necessary mechanisms and an assortment of nozzle plugs and pipe reducers. Later, eight more meters of the same kind were added. After a preliminary survey of the entire layout it was evident that the pumping situation was the most serious and needed immediate attention. The first pumping plant investigated, located 250 ft. underground, consisted of four simple duplex direct-acting noncondensing pumps, each of 2000 gal. per min. rated capacity, and two duplex compound condensing pumps, each of 4000 gal. per min. capacity. The condensing pumps were equipped with low vacuum jet condensers. These six pumps were located in three adjoining pumprooms, two of which were partly submerged during periods of high water.

Steam was supplied from a modern boiler plant on the surface, at a distance of 2500 ft. The steam main was a 10-in. pipe for a distance of 600 ft., then branching to two 8-in. mains to the pumps. Bypass connections at the pumps allowed any set of pumps to be operated from either 8-in. line, and connections at the foot of the borehole, where the 10-in. pipe branched, allowed either 8-in. pipe to be supplied from an old boiler plant.

It was decided that the required information could best be obtained by determining the characteristic curves of the various pumps separately and in combination. For this purpose three meters were installed on the steam lines to the pumps. A double-end contracted weir was built on the surface to measure the discharge of the pumps, and engine indicators were used to determine the indicated horsepower, mean effective pressure, length of stroke, etc.

One of the three meters was connected on the surface to the 10-in. steam line. The other two were located inside the mines, on the 8-in. lines, 1600 ft. from the pumps. Each instrument had a calorimeter and recording pressure gage connected near-by. In order to meet accurately the wide range of flow necessary for the tests, one of the meters inside was connected to two nozzle plugs, one an 8-in. and the other an 8 x 5½-in. reducer.

In order to get the meters installed it was necessary to load them in mine cars, lower them down a slope to a gangway, haul them by mule to the airway where they were to be installed and finally carry them to the points chosen for their location. There the meters were unpacked, assembled and adjusted.

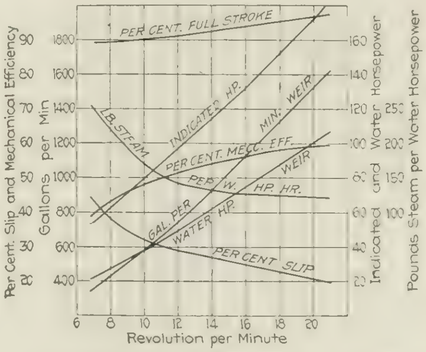


FIG. 2. CHARACTERISTIC CURVE OF DUPLEX NONCONDENSING PUMP

Steam end, 24 x 36 in.; water end, 14 x 36 in.; head, 254 ft.; suction, 6 ft.; steam pressure, 125-134 lb.

The accompanying curves are some of those taken during this investigation. Fig. 1 was taken from tests on a duplex compound condensing pump and Fig. 2 from a test on a duplex noncondensing pump. These

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*From *Coal Age*.

tests, it should be borne in mind, were taken after the pumps had been installed several years. The steam-consumption curves also include condensation losses in pipe, etc. The tests were made with the steam lines and pumps in the condition in which they were found and as ordinarily operated. They were in fairly good repair.

An analysis of the curves showed several important facts. The difference in steam consumption per water-horsepower between the compound condensing pumps and the simple noncondensing pumps was particularly noticeable. It was, of course, recognized that one type was more efficient than the other, but the large difference in economy was more easily seen by obtaining definite figures under similar operating conditions. This one item has been of much value in numerous other pumping installations, since it emphasized the facts in a way that no estimated figures have been able to do.

Another point demonstrated by the test was the lack of capacity of the pumps. The condensing pumps were rated at 4000 gal. per min. at 22 r.p.m., but they could not be safely operated above 3000 gal. per min. Their best operating capacity from a standpoint of repairs and upkeep was at 1700 to 2000 gal. per min., while their best efficiency was obtained at about 3500 to 4000 gal. per min., a rating at which they could not be operated. This not only explained the difficulty experienced in caring for floods, but also showed a wastage of about 3000 tons of coal per year due to the necessity of using the noncondensing pumps even in low-water periods.

As a result of these tests two 2500 gal. per min. electrically driven centrifugal pumps have been installed and have effected a fuel saving of about 4500 tons of coal per year. In addition, and of equal importance, is the fact that production is not now curtailed during periods of high water.

It might be interesting to note that the totals of the two inside flow meters checked within 2 per cent. of the meter on the outside 10-in. main.

After the foregoing tests had been completed a series of boiler and power-plant tests were carried out. The primary purpose of these trials was to determine power costs, boiler-plant efficiencies and, in the case of the generating plants, efficiency from the coal pile to the switchboard.

The size of the boiler plants varied from 1500 to 4000 hp. and the electric plants from 1400 to 3000 kv.-a. For these tests platform scales were used for weighing the coal. Flow meters were installed on individual boilers and on the distributing steam mains. Other equipment included feed-water flow meters, draft gages, recording pressure gages, flue-gas thermometers, Orsat analyzer, electrical instruments, etc. The plant tests were of one week duration. Individual boiler tests of 25 hours were made, checking a flow meter against the feed water measured in calibrated tanks.

TYPES OF BOILERS THAT UNDERWENT TESTS

The types of boilers tested were horizontal return-tubular B. & W., Stirling and Wickes. The furnaces were of the dutch-oven type, with sloping 18 per cent. air space dumping grates. Steam-jet blowers furnished forced draft in the smaller plants and engine-driven fans in the larger ones. The fuel was a mixture of No. 1 buckwheat and birdseye anthracite containing 10 per cent. moisture and 15 per cent. ash. The conditions, from a metering standpoint, were often difficult because of low velocity and pulsating flow. Nevertheless, the average error was seldom over 2 per cent, and in only one instance 10 per cent.

From the standpoint of the engineers and helpers making the test the conditions were equally trying. Boiler-room temperatures varied from 125 deg. F. down to 10 deg. Meters on steam mains, although filled with strong alcohol solution, frequently froze. Those mounted on boilers did freeze occasionally, and at times draft gage and Orsat readings were only possible by building fires on old grate bars directly under the instruments.

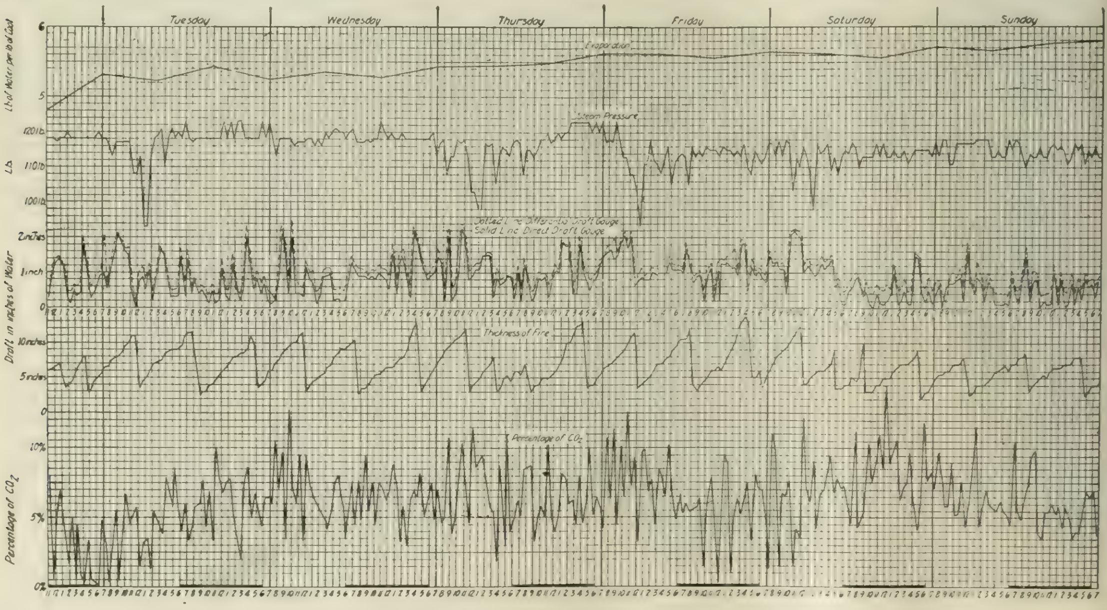


FIG. 3. EVAPORATION OF ONE BOILER FROM READINGS TAKEN IN A SIX-DAY TEST

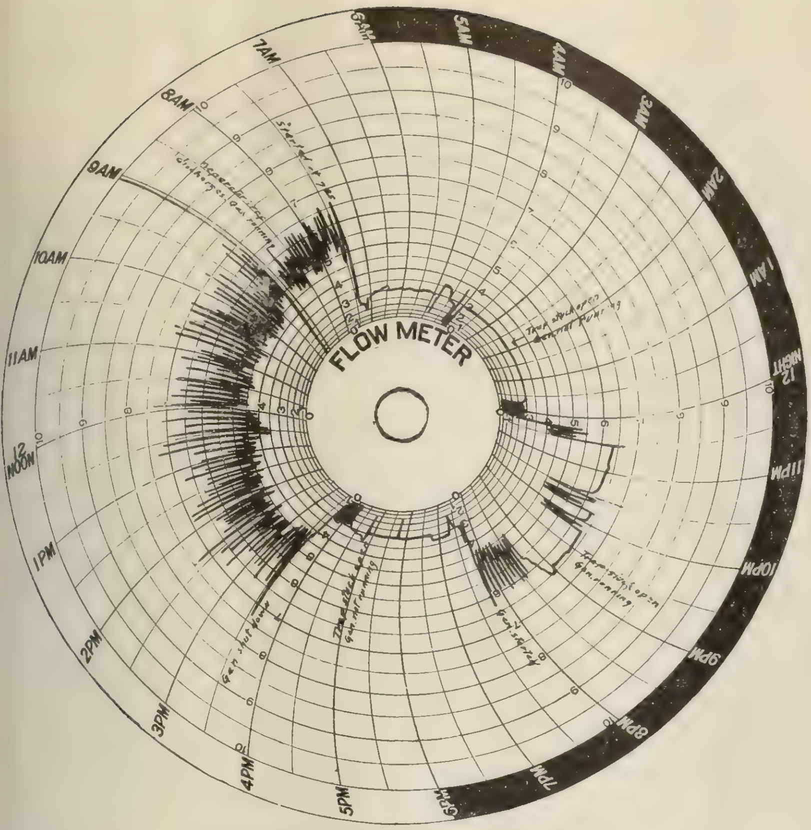


FIG. 4. A 24-HOUR FLOW-METER CHART

Power costs and distribution ratios were determined from the flow meters. The boiler units showed a general lack of capacity and a low efficiency; an average of 125 per cent. rating was the best the most modern plants could develop.

The curves shown in Fig. 3 indicate the evaporation of one boiler plotted from readings taken during a plant test of six days. The boiler was a 270-hp. Stirling. The test was made without instruction or otherwise interfering with the usual operation of the plant, the object being to obtain, as nearly as possible, the usual operating conditions.

In view of the extreme care taken to secure normal operating conditions, the rise in the evaporation curve from 4.8 lb. of water per pound of coal as fired to 5.8 at the end of the test is of interest. This curve gives an excellent illustration of the value of checking results. The increase in evaporation was due entirely to the firemen bettering their efforts as they realized they were being investigated.

Fig. 4 shows a flow-meter chart taken in one of these tests. The meter was placed on the line supplying a 300-kw. compound noncondensing Corliss engine driving an alternator. The high momentary demand lines with the engine shut down and with it running should be noted. An investigation disclosed the fact that the trap on the boiler-room header was out of order. The water from the header had been going to the engine separator and was thence discharged by the trap, causing the lines on the chart already referred to. It showed also that the separator traps frequently stuck open, allowing a steam wastage of 100,000 lb. per 24 hours. Repairing the traps remedied this trouble. In addition to disclosing a condition that might have wrecked the engines eventually had the separator traps failed to open, it was figured that the stopping of steam waste would pay for all the meters in one month's operation. After the results of these tests had been fully tabulated and analyzed, certain recommendations were made to the owners, one of which was the replacement of 15,000 sq.ft. of grate surface by new grates of smaller air space and the addition of 10 mechanical stokers. The foregoing tests, and the benefits that will accrue from them in the way of increased efficiency and fuel saving, represent a phase of engineering work in which the flow meter finds its rightful place. In many power plants there are actions going on or equipment improperly functioning which will finally make itself evident; but in many of the cases these discoveries are made only after considerable damage has been done. It is in such instances that these meters prove themselves a valuable aid.

Congress Should Unlock Water Powers

Passage of the Congressional water-power bills now in conference is earnestly to be hoped for before the close of the present session. Every engineer who is familiar with the water-power situation will agree that prompt action is needed. Water-power needs to be unlocked, to conserve fuel and to furnish profitable employment to the men released from military service and munition making. The present Congress has given more attention and study to this vital matter than any previous Congress. Its work should not be lost, especially at this critical time. Even if the bill as finally reported should be more or less of a compromise and defective in many particulars, yet if, without undue sacrifice of vital interests on either side, it opened the way for even a limited development of unused water powers, it would be well worth while as a contribution to the solution of reconstruction problems and to the conservation *and utilization* of our natural resources. — *Engineering News-Record.*

In the oil fields, a "gusher" becomes a "pumper" when its flow decreases to one or two hundred barrels a day.

The Electrical Study Course—Parallel Operation of Generators—III

Concludes the series of lessons on this subject with a study of the condition to be met in the practical operation of compound generators and the precautions to be observed when placing them in service or removing them therefrom.

THE previous lesson dealt with the methods of cutting-in and cutting-out shunt generators when several of them are operated in multiple. In the present lesson the problem as related to compound generators will be taken up in a similar manner.

In Fig. 1 are shown the connections for a compound generator corresponding to those shown for a shunt generator in the preceding lesson and which are reproduced in Fig. 2. The symbols in Fig. 1 indicate the same appliances that they do in Fig. 2, and in addition are shown the series-field winding F_s and the equalizing connection B, which is a busbar similar to M_1M_2. The operation of placing the machine in service, that is, parallelling it with another machine, is identical with that for a shunt generator, except that its voltage is adjusted to be a few volts less than that of the mains instead of equal to it. The reason for this is, that when the switch S is closed current immediately flows through the series-field winding F_s, causing the generator to be supplied with excitation additional to that of the shunt field and consequently inducing a greater generated voltage in it. The simplified diagram of Fig. 3 will make this clear. In it three generators, G_1, G_2 and G_3, are shown. G_2 and G_3 are connected to the mains M_1, M_2 and to the equalizer B, and G_1 is to be paralleled with them. Suppose the voltage across ac is made equal to that across df. This same voltage will exist across ab and there will be zero voltage across bc since there is no current through the series field F_1 and consequently no voltage drop—that is, IR drop—across it. On the other hand, there *will* be a voltage across ef equal to the drop across the series fields F_2 and F_3; that is, equal to I_tR_t, where I_t is the total load current and R_t the resistance of F_2 and F_3 in multiple. Since there is a voltage across ef, the voltage across de must be less than that across ab if the latter is equal to that across df, as assumed. We therefore have the following conditions when switches S_a, S_b and S_c—corresponding to switch S of Fig. 1—are closed: The generated voltage across ab is greater than the terminal voltage across de, consequently the generator will deliver current to the system. But in addition to this we have, as already stated, an increase in excitation due to current being caused to flow through the series field F_1. That current will flow is evident from the fact that F_1 is connected to b and c, which are connected to e and f respectively when switches S_b and S_c are closed. Since there is a voltage across ef and none across bc, it follows that current will flow through F_1 when connected to the former points, causing the increase in excitation referred to.

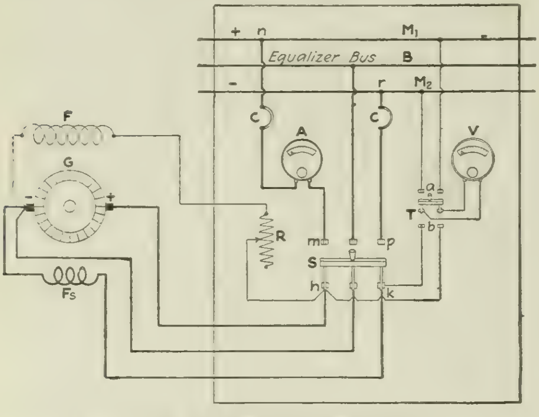


FIG. 1. DIAGRAM OF COMPOUND-WOUND GENERATOR CONNECTED TO SWITCHBOARD

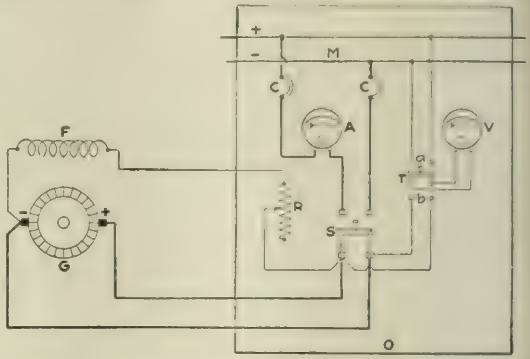


FIG. 2. DIAGRAM OF SHUNT-WOUND GENERATOR CONNECTED TO SWITCHBOARD

Just how much less than the line voltage the open-circuit voltage of the incoming generator should be is a matter of trial. Having once been determined, the operator adjusts it to that value whenever cutting-in the machine. A method of avoiding the complications indicated in the foregoing is to substitute a double-pole and a single-pole switch for the three-pole switch S of Fig. 1. Such an arrangement is shown in Fig. 4. In this case the generator is adjusted to approximately line voltage with the field rheostat and then the double-pole switch S_d is closed, thus connecting the series field F_s across M_2 and B, across which are already connected the series fields of all the other generators serving the busbars. Current consequently flows through F_s as explained in the preceding paragraph, thereby increasing the voltage of the generator. This is now adjusted to exactly the same value as the line voltage, as in the case of shunt generators, and the single-pole switch S_s is then closed, thus placing the machine in service.

Having connected a compound generator to the line, the load upon it is adjusted in the same manner as for a shunt generator; namely, by increasing its shunt-field current by cutting resistance out of the shunt-field rheostat. When it is desired to take it out of service, the shunt-field resistance is increased until the excitation has been reduced sufficiently to cause the ammeter *A* of Fig. 1 to indicate zero current, upon which switch *S* of Fig. 1 or switches S_s and S_d *of* Fig. 4, as the case may be, are opened and the set shut down.

The voltmeter arrangement for shunt generators illustrated in Fig. 5 of the previous lesson and which is reproduced in Fig. 5 herein, is also used for compound machines, the points *h* and *k* of this figure corresponding to the same points in Figs. 1 and 4.

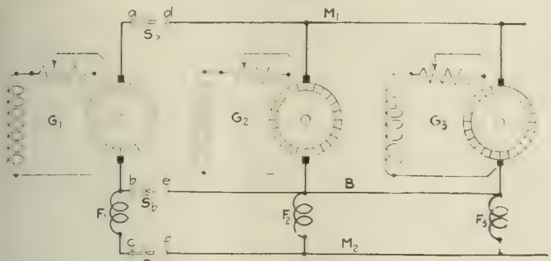


FIG. 3

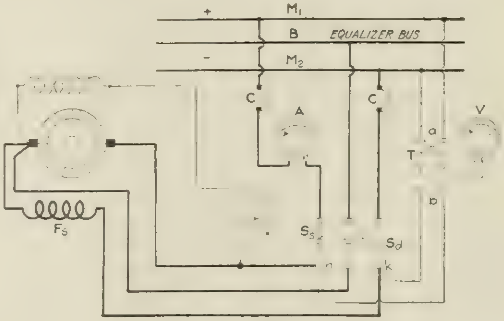


FIG. 4

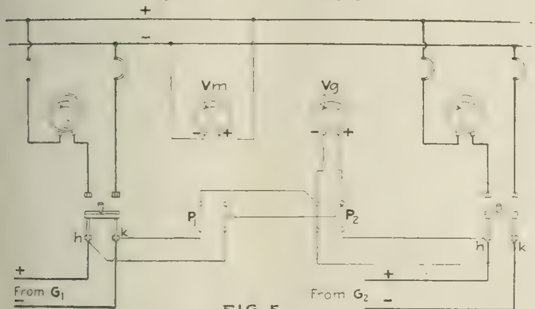


FIG. 5

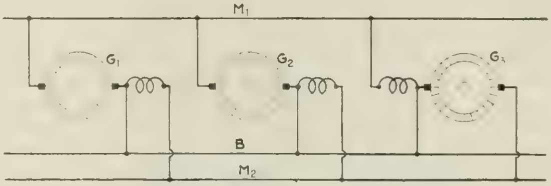


FIG. 6

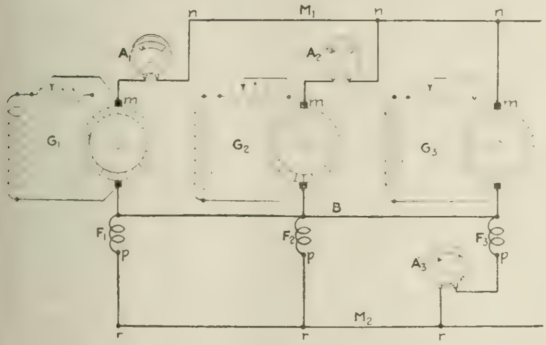


FIG. 7

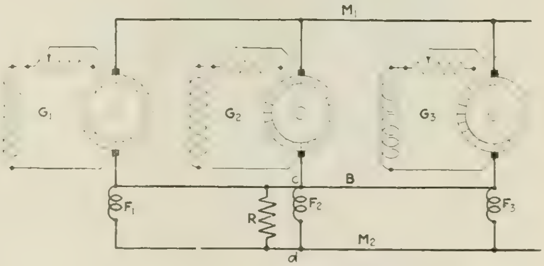


FIG. 8

FIGS. 3 TO 8. SCHEMATIC DIAGRAMS OF COMPOUND-WOUND GENERATORS OPERATING IN PARALLEL

It is to be observed that the series fields of all the generators operating on the system must be connected between the same main and equalizing busbars. For example, it would not do to connect the series field of generator G_3 of Fig. 6 between M_1 and *B*, as shown, if the series fields of G_1 and G_2 are connected between M_2 and *B*. All the fields would have to be connected either one way or the other. Another point to be noted is that the ammeter for measuring the output of the generator must be connected into the side of the circuit opposite to that in which the series field is. For instance, it would be incorrect to insert the ammeter *A* of Fig. 1 in the circuit between *p* and *r* instead of between *m* and *n*, where it is shown in the diagram. In the former case the ammeter would indicate the current flowing through the series field and not that through the armature, which is the current being delivered by the machine. As was explained in the lesson in Jan. 7 issue, the total current divides up equally among all the series fields, provided they are of like resistance, irrespective of the loads carried by the machines, which depend upon the generated voltage of each.

That the ammeter will indicate the armature current when connected between *m* and *n* as in Fig. 1, but would indicate the series-field current if connected between *p* and *r* is clearly shown in Fig. 7 which is a schematic diagram of several generators connected as is the one in Fig. 1. The busbars in each are represented by the same symbols, namely M_1, M_2 and *B*, as also are the points *m*, *n*, *p* and *r*. The ammeters A_1 and A_2 of generators G_1 and G_2 are correctly connected, whereas ammeter A_3 of generator G_3 is incorrectly connected. Assume the resistances of all the fields F_1, F_2 and F_3 to be the same, and that G_1 is delivering 50 amperes, G_2 60 amperes, and G_3 85 amperes, making the total load 195 amperes, and the current in each series field one third of this, or 65 amperes. We would then have ammeter A_1 reading 50 amperes and ammeter A_2 reading 60 amperes, which would be the correct value of currents delivered by G_1 and G_2, but ammeter A_3 would read only 65 amperes although the current actually delivered by G_3 is 85 amperes.

Adjusting the amount of compounding of compound generators that operate in multiple introduces a problem not present when a single machine is used. The accepted manner of adjusting the compounding is to place a shunt of a low resistance and large current-carrying capacity across the series-field winding, thus diverting some of the line current from the latter and thereby reducing the series-field effect. However, when compound generators are operating in parallel the effect of placing a shunt across one of the series fields is to place a resistance in parallel with them all, since they are all connected between the same busbar and equalizer. A reference to Fig. 8 will make this clear.

Suppose a resistance R to be placed across F_2. Being connected between B and M_2, it is evident that it is in multiple not only with F_2, but also with F_1 and F_3. The consequence is that part of the load current will pass through R and the remainder will divide between F_1, F_2 and F_3 in the same ratio as before R was introduced. It is therefore impracticable to adjust the compounding by this method. It is, however, often necessary to make such adjustments in order to cause the generators to have like external characteristics, and in that case the distribution of current among the series fields may be effected by placing resistances in series with them. Thus if R of Fig. 8 were placed in series with F_2 instead of in parallel with it, the total resistance between c and d would be increased and consequently less of the total current would flow through it than before. Suppose, for instance, that the resistances of F_1 and F_2 are each 0.05 ohm, and that of F_3 is 0.04 ohm. If the total current were 130 amperes we would have 40 amperes each through F_1 and F_3, and 50 amperes through F_2. To make the current divide equally among all the fields, it would be necessary to insert a resistance $R = 0.01$ ohm in series with F_2, making the total resistance across cd equal to 0.05 ohm, to correspond to the resistances of F_1 and F_3.

In the problem of the preceding lesson it was stated that two 100-kw. 230-volt shunt generators were operated in parallel, and that the armature resistance of each was 0.01 ohm. It was required to find what the total load current would be if the generated voltage of one machine was 234 volts and that of the other 233 volts. The total current will of course be the sum of the individual currents, and the individual currents are determined by the generated voltage, terminal voltage, and armature resistance. That is, $I = \frac{E_g - E}{R}$, where I is the current, E_g the generated voltage, E the terminal voltage, and R the armature resistance. In the case of the first generator we have, $I = \frac{234 - 230}{0.01} = 400$ amperes, and for the second, $I = \frac{233 - 230}{0.01} = 300$ amperes. The total current will therefore be $400 + 300 = 700$ amperes.

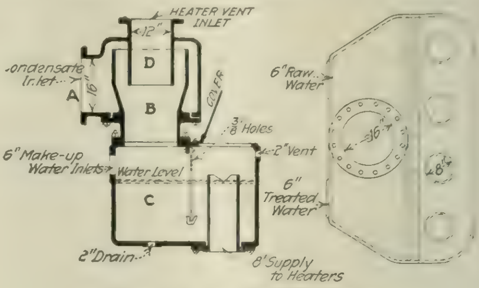
Three compound generators are operated in parallel. They are of the following capacities: 50 kw., 100 kw. and 200 kw. If the series field of the 50-kw. machine has a resistance of 0.01 ohm, what should be the resistances of the series fields of the other two?

Dividing Box with Condensing Head

By Howard C. Thayer

A dividing box with condensing head, designed by the writer for use in power stations using two or more open-type feed-water heaters, is shown in the drawing. The dividing box is designed to distribute the water equally to any number of heaters. The purpose of the condensing head is to condense the large quantity of exhaust steam which at present goes to waste through the vent pipes, and at the same time it keeps the heater free of air.

In operation the hotwell pumps discharge the condensate water through the 16-in. inlet A, where it rises up and flows over into 21-in. cone B and into dividing box C. As the water falls through the cone, it forms a vacuum which draws over the steam and air in the vent pipes through the central 12-in. opening D, condensing the steam and allowing the air to escape through the perforated plate E and the 2-in. vents in the dividing box.



DETAILS OF DIVIDING BOX

Two makeup water inlets are provided in the dividing box, permitting the treated water to be controlled by a float box at the nominal water line of the heater and the raw water to be controlled by a float box operating at a lower level. In ordinary operation only treated water is fed into the dividing box, but should the water level in the heater be pulled below the normal line at any time the raw water is admitted until the normal water line is reached.

The author of the article, "Relative Advantages of Diagonal and Horseshoe Boiler Patches," beginning at the foot of page 943 in the issue of Dec. 31, 1918, asks that a statement be published to the effect that the diagonal patches should be placed on the inside of the shell plate instead of on the outside as shown in the illustration.

The Coal Department of Denver has extended its free delivery zone. This change relieves a greater number of consumers from overhaul charges, and has at the same time reduced the overhaul rate from 50c. to 25c. per mile for those beyond the free zone.

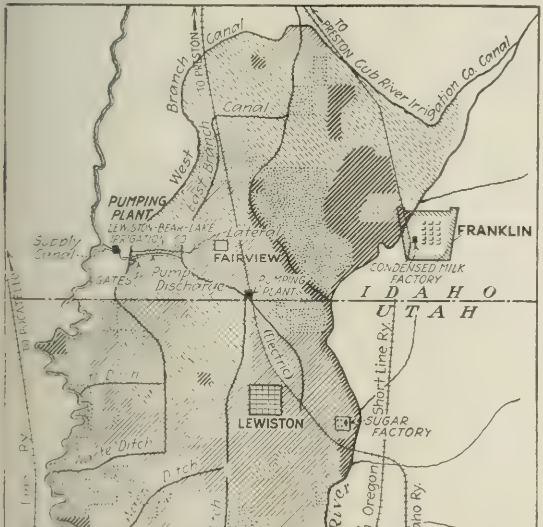
High-Lift Centrifugal Pumps for Irrigation

By B. P. FLEMING*

Water forced through steel manifold to reinforced-concrete conduit leading up to canal. Design features. Pump tests show over 81 per cent. efficiency under 90-ft. head.

EVERY year sees greater strides made in irrigation by pumping. This article describes a new high-lift irrigation pumping project with steel manifold and reinforced-concrete force main, put in successful operation in 1917 for supplementing the water supply of a large area known as the "Lewiston Flat" in northern Utah and southern Idaho. Power at low cost as well as intensive agriculture makes high-lift pumping feasible.

The irrigable area of the district has been estimated at about 30,000 acres, of which about 20,000 are under existing canals. For the last 40 years the water-supply has been derived from a small stream known as the Cub River, a tributary of the Bear River. The flow of the Cub varies from about 400 sec.-ft. in June to an amount not exceeding 60 sec.-ft. in July and August, during which months the sugar-beet crop is most in need of water. In normal years about 8000 acres of the Lewiston district would be fairly well supplied with water over the entire season, 8000 acres would receive only sufficient to grow grain crops or mature one crop of hay, while 4000 acres might receive no water at all.



CLASSIFIED DISTRIBUTION OF LANDS IN LEWISTON FLAT IRRIGATION PROJECT, IDAHO AND UTAH

The Bear River lies from 85 to 90 ft. below the general level of the lands in question. Its natural flow has been appropriated by agricultural and other interests along its course in Idaho and Utah, so that the only hope of the district was in securing a right to stored water. This, fortunately, was obtainable through the extensive storage developments begun by the Telluride Power Co. and completed by its successor, the Utah Power and Light Co., on the body of water known as Bear Lake, in northern Utah. This development comprised the construction of a large pumping plant of 1500 sec.-ft. capacity and control gates which, together with an artificial channel between Bear Lake and the Bear River, make it possible to divert floods into the lake and store them there or, in case of long-continued drought, permits the pumping out of the waters of the lake to a depth of 17 ft. below the normal stage and thereby augmenting the flow of the river.

OBJECT OF THE DEVELOPMENT

The object of this development is to insure continuity of operation of the large hydraulic power plants established on Bear River, but, incidentally, it has assisted to a certain extent in the possibility of agricultural development, by providing some stored water for the use of those who are able to secure a right to it and who can divert it below the power plants. The attractive rates for electrical power for pumping offered by the power company, together with the offer of a right to a certain amount of stored water, led to the inception of the project here described. The amount of water estimated as necessary to be supplied by pumping, to supplement gravity water, was 10,000 acre-ft. Since this amount must be supplied mainly within a period of 50 days, the capacity of the plant became fixed at 100 sec.-ft. For flexibility in operation it was decided arbitrarily to build a plant of four units of 25 sec.-ft. capacity each.

The plant was located directly west of Fairview, Idaho, at which point the Bear River approaches quite near to the present canal system of the Cub River Irrigation Co., into which the pumped water was to be discharged.

The distance through which the water would have to be carried under pressure, in the case of a plant located at the river, and the size required, seemed to indicate that only a wood-stave pipe could be considered from the standpoint of initial cost—and this fact was of the greatest weight in the decision to adopt the other type of plant.

Another factor having an important bearing on the general design of the pumping station was the type of pump to be selected, whether vertical or horizontal. This matter was not decided until after bids had been

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*Mechanical engineer, Iowa City, Iowa, in *Engineering News-Record*.

received upon both types. It is significant of the favor with which these two types of units are regarded by the pump manufacturers themselves that, out of seven manufacturers represented, only one would offer a bid upon the vertical unit, and the others were most decidedly opposed to its use under the circumstances.

After various studies had been made, it was found that a concrete pipe was practically as cheap as a riveted steel pipe of the same internal diameter, so concrete was decided upon because of its greater permanency and lower friction loss, as well as the less difficulty in securing construction materials. The design of a reinforced-concrete manifold to receive the discharge from the four pumps proved to be so difficult that it was abandoned in favor of a riveted steel manifold. The full-discharge velocity throughout the manifold and the concrete pipe was limited to 5 ft. per second, and in the design of the manifold an attempt was made to give the easiest flow lines possible while yet maintaining a form providing a maximum of strength. The manifold has a circular section in every part, and in order to insure additional stiffness a vertical plate is riveted in the crotch of the breech-like portion. No leak of consequence was discovered in any of this riveted steel construction.

PRESSURE EFFECT FROM SUDDEN CLOSING OF GATE VALVES

Some concern was felt by the designers as to the probable pressure effect in the steel manifold and the concrete discharge pipe resulting from sudden closing of the hydraulic gate valves on the discharge side of the pumps. If, for any reason, power goes off while the pumps are in operation, the pumps almost immediately begin to run backward, and the water in the discharge pipe attains a fairly high velocity backward down the pipe. Checking this flow suddenly by the closure of the gate valve would cause water-hammer. Calculations, based on the various formulas tried, while not giving consistent results, seemed to indicate that no dangerous pressures would be developed. A small relief valve was, however, placed at the end of the steel breeching. In the operation of the plant and in the deliberate creation of conditions favorable for water-hammer at the time of testing, scarcely appreciable rises in pressures were noted.

A vacuum relief valve was also placed at the top of the concrete pipe at Sta. 14 + 17, at which point there is a break in vertical alignment where vacuum conditions may be created by the rapid letting out of water from the pipe. The free area of the air valve is about 1 per cent. of the area of the pressure pipe.

Excessive temperature changes in the concrete and steel piping were anticipated, since, although backfilling over the concrete pipe was proposed, it was not of sufficient thickness to insure against considerable daily and seasonal temperature changes, while the steel piping was completely exposed. Expansion joints in the concrete pipe were considered, but the difficulty of construction and the possibility of leakage led to the rejection of expansion joints altogether in the concrete pipe and the placing of dependence upon the longitudinal reinforcement alone to prevent the formation of transverse cracks. It was planned also to construct the pipe in cold weather, and this was successfully accomplished by late spring, before hot weather had set in. No leaks of any magnitude have so far (April, 1918) appeared in the pipe although water was turned into it for the first time early in July, 1917, when there was probably 50 deg. difference in temperature between the pipe and the water. Expansion joints were introduced in the steel piping of the manifold next to the pumphouse, and the pump side of the joint was anchored securely to piers braced against the pumphouse foundation.

To drain the sump beneath each main pump unit, there is a 3-in. motor-driven side-suction centrifugal pump, with a valve-controlled 4-in. suction pipe. For priming the main pumps and the sump pump, a motor-driven rotary vacuum pump is provided, its suction being connected to a vacuum main from which branches lead to each pump. To the priming pump, immediately above each main unit, is attached a gage-glass by which the operator can tell exactly when the unit is primed. Some difficulty was met in the initial operation of the priming pump, due to inexperience in adjusting the amount of water needed for water-sealing it. When finally adjusted, it would prime a main unit in from 5 to 7 minutes.

WATER FROM RIVER IS PUMPED THROUGH STEEL MANIFOLD AND REINFORCED-CONCRETE CONDUIT

The hydraulic gate valves are 18 in. in size and are provided with a hand operating device for use when the pumps are first started and no pressure head is available in the discharge line for their operation. This device was found by no means satisfactory, since its design requires an entire dismounting before the valves can be operated hydraulically. The control of the hydraulic valves is centralized at a point near the switchboard, so that after priming a unit and starting the motor the operator merely turns a small pilot valve which opens the main valve. A reverse motion of the pilot valve likewise closes the main valve, so that the operation is very easy and rapid. Hydraulically rather than electrically operated valves were chosen because of their greater simplicity and much smaller first cost. Their operation in this plant has been eminently satisfactory.

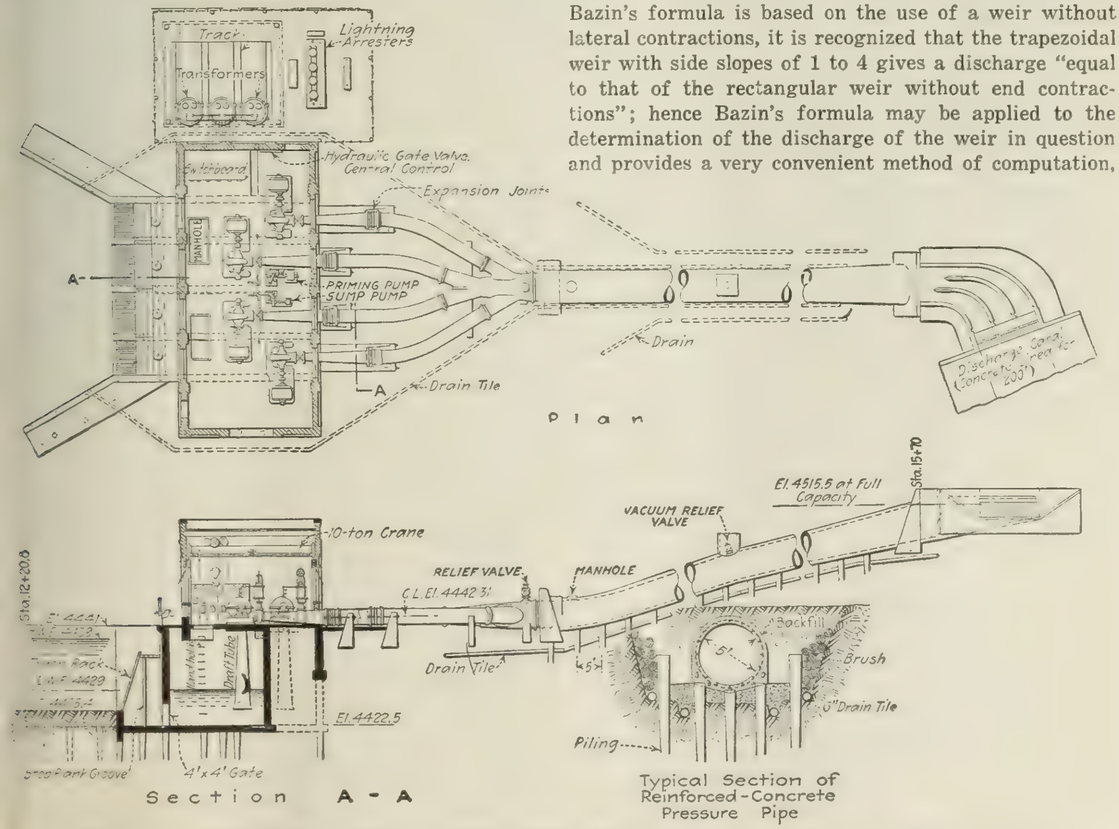
Each main pump unit is an 18-in. double-suction split-case centrifugal pump with bottom horizontal discharge and vertical suction connection. The impellers are of bronze, and a bronze sleeve covers the shaft from the impeller out through the stuffing-boxes. The latter are water-sealed and were provided with bronze lantern rings.

Water for sealing was taken originally from the pumps themselves, which necessitated tightening the glands when priming. It is now proposed to utilize clear water from a spring near the station, which will give sufficient water under pressure for water seal irrespective of the operation of the pumps.

The pumps are provided with ring oiling bearings in split babbitt cases. A flexible coupling attaches the pump to a 350-hp. induction motor on the same bedplate. These motors are three-phase 60-cycle, of the squirrel-cage type, using current at 440 volts. Each motor is controlled from its own switchboard panel, the cable running in a conduit laid in the floor.

The current is transmitted to this station from the Preston substation, about six miles away, at 44,000 volts. Current is transformed into the 440 volts used at the plant by a bank of three 500-kv.-a. transformers of the outdoor, oil-filled, air-cooled type. Four 44-kv. aluminum-cell lightning arresters are provided for protection against line surges and lightning discharges, and the other equipment includes disconnecting and line switches, choke coils, expulsion fuses, etc. Serious difficulty experienced in times of electrical storms with high potential discharges on the secondary side, soon after operation was started, led to the installation of secondary arresters between the transformers and the switchboard, in addition to the more thorough grounding and transformer cases.

The contract between the pumping enterprise, or the Lewiston-Bear Lake Irrigation Co., and the Utah Power and Light Co. comprises many features intended to penalize peak-load conditions and to encourage an endeavor to economize on power consumption, although the base rate is only 1c. per kw.-hr. In the design of the plant, therefore, an effort was made to eliminate so far as possible hydraulic-energy losses in piping and sumps, and in preparing the specifications an efficiency for the pumping units themselves of 81 per cent. was demanded. This was considered a not unattainable ideal, but one of the largest pump manufacturers in the country refused to bid upon the basis of this figure, and several other manufacturers were very loath at first to offer to attain this efficiency, particularly since the contract was so worded that a certain percentage of the contract price was to be withheld pending the attainment of the guaranteed efficiency. Inasmuch as this percentage amounted to $12,000, the contract provided for complete tests of the pumps upon completion of the plant. Considerable thought was given to the matter of accurate water measurement. After rejection of other methods because of difficulty of operation or probable inaccuracies, it was decided to install a 14-ft. Cippoletti weir in the discharge canal, 200 ft. below the outlet of the discharge pipe and at the end of the concrete-lined section of the canal. The weir was constructed of 2-in. grooved and tenoned lumber with a thin steel plate for the weir crest, the weir being installed in a substantial concrete structure, with provision for removing the weir board upon completion of the tests. Heads on the weir were measured by a hook gage reading to thousandths of a foot, the zero of which was determined by an engineer's level. Bazin's formula, as tabulated in Williams and Hazen's tables, was used for calculating weir discharge. Although Bazin's formula is based on the use of a weir without lateral contractions, it is recognized that the trapezoidal weir with side slopes of 1 to 4 gives a discharge "equal to that of the rectangular weir without end contractions"; hence Bazin's formula may be applied to the determination of the discharge of the weir in question and provides a very convenient method of computation,



LAYOUT OF CENTRIFUGAL PUMPING PLANT, STEEL MANIFOLD AND CONCRETE DELIVERY CONDUIT inasmuch as velocity of approach is taken into account in the formula and may be neglected when the weir conditions are comparable to those of Bazin, which it was the endeavor to secure in this case.

Pressure head on the pumps was determined by a calibrated Bourdon gage and suction head by a mercury manometer, both being referred to the axis of rotation of the pumps as a datum. Power input to the motors was measured at the motor terminals by an indicating polyphase wattmeter, current transformers only being used. Merely as a check, the readings of the switchboard instruments were taken during the test, but were not used in making calculations. Subsequent to the test the gages and electrical instruments were calibrated, and these calibrations were used in making the official calculations. In calculations of pump efficiency the motor efficiency was assumed as that shown by factory test at full load, 91 per cent.

TABLE I RESULTS OF CENTRIFUGAL IRRIGATION PUMP TESTS

Unit No.	Discharge Head, Ft	Suction Head, Ft	Total Head, Ft	Static Lift, Ft	Discharge, Sec Ft	Water H P	H P Input	Pump Efficiency, %	Speed
1	70.1	18.2	88.3	85.35	28.36	284.5	344.6	82.5	886
1	75.8	17.7	93.5	85.26	27.51	292.0	347.6	84.0	883
1	81.5	16.75	98.25	85.05	25.95	290.0	344.4	84.2	889
2	70.1	18.1	88.2	85.34	27.69	277.5	344.4	80.6	880
2	75.3	17.5	92.8	85.20	26.82	282.8	347.8	81.3	880
2	80.5	16.9	97.4	84.90	25.76	285.0	350.0	81.4	882
3	70.1	18.3	88.4	85.23	28.52	286.2	341.6	83.8	
3	74.8	18.1	92.9	85.24	27.81	293.6	344.6	85.2	
3	81.0	17.4	98.4	85.38	26.09	291.9	341.6	85.4	
4	69.9	18.6	88.5	85.55	27.72	278.3	339.6	81.9	884
4	74.8	17.9	92.7	84.91	27.22	286.3	343.5	83.4	882
4	80.3	17.2	97.5	87.79	26.32	291.4	344.0	84.7	880
1, 2, 3, 4	71.1	17.4	88.5	85.8	108.01	1086.0	1421.5	76.5	.

In testing (see Table I), the pumps were each run separately at three heads, the heads being varied by partly closing the hydraulic gate valves. Following the runs of the individual pumps all four were operated together to determine the action of the manifold as regards friction effect.

The most significant figures in Table I are those on pump efficiency. It will be seen that efficiencies of over 85 per cent. were attained by No. 3 unit, while all units are safely over the guaranteed efficiency of 81 per cent. at 90-ft. head. The lower efficiency of No. 2 unit is thought to be due to a small air leak in the suction pipe. This leak was not discovered until the tests had been completed. With all the pumps in operation there is noted a distinct falling off in pump efficiency which is difficult to explain, since there is no apparent reason why an efficiency determined for the four units working in parallel should not be the mean of their individual efficiencies at approximately the same conditions of head and discharge.

TABLE II. FRICTION LOSSES BETWEEN DISCHARGE CANAL AND FOREBAY

Unit No.	1	2	3	4	Four in Parallel
Total static lift, ft ..	85.35	85.34	85.23	85.55	85.8
Discharge head, ft. .	70.1	70.1	70.1	69.9	71.1
Suction head, ft . .	18.2	18.1	18.3	18.6	17.4
Total head, ft	88.3	88.2	88.4	88.5	88.5
Friction head, ft.......	2.95	2.86	3.17	2.95	2.7
Discharge, sec-ft	28.35	27.69	28.52	27.72	108.01

Table II illustrates the apparently anomalous condition of friction head decreasing as discharge increases. This is probably due entirely to the better flow conditions established in the steel manifold when all four branches are discharging than when one only is being used, so that the saving of head here more than overbalances the greater loss in the concrete pipe due to the increase of velocity when carrying 108 second-feet.

As a whole the efficiency tests of this plant illustrate the recent remarkable advance in centrifugal-pump design from the standpoint of efficiency and give reason to believe that it is not too much to expect that in the case of large units, working under reasonably high heads, 85 per cent. efficiency may be obtained where the character of the installation is such as to warrant the extra expense of a pump designed for the special conditions under which it is to operate. It is to be noted that such efficiency can be obtained only by the use of small running clearances in the impeller at the wearing ring which prevent leakage from the discharge back to suction; and the water seal preventing air leakage into the suction passage around the shaft must be perfectly air-tight. Wear is to be expected in the course of time in the wearing rings, and the glands cannot be maintained in perfect condition after a long period of use, so that to maintain the high efficiency found when the installation is new it will be necessary to renew from time to time the wearing rings and the bronze sleeves on the shaft.

The Factor of Safety

By J. R. Belknap

In engineering design the factor of safety will play an important part when we have to get down to bedrock competition with the rest of the world in engineering products. For example, suppose one designer figures a machine with a factor of safety of 4 and another designs a similar machine with a factor of safety of 6. Evidently, the first has a decided advantage as to saving of material and weight and therefore price.

Some time ago a concern bought a centrifugal pumping unit which was about the lightest and cheapest thing on the market. However, it was the only thing to be had on short delivery. Realizing what kind of a machine it was, I made a special effort to get a good foundation under it, to see that the piping made no strains in the frame and that it was carefully lined up. When setting up a centrifugal pump, the coupling bolts should be left out until all suction and discharge piping is done, because no matter how well it may be lined up a pipefitter can easily pull it out of line. This plan was followed with the pump mentioned, with the result that it has never given any trouble. The efficiency is good and is maintained under a wide load range.

A learned professor once dubbed the factor of safety, "Factor of Ignorance." I would suggest "Factor of Experience."

When an oil engine is made that breaks a crankshaft, breaks another and then another, that is pretty good evidence that the crankshaft has too small a factor of safety, no matter what figures the designer might show to prove to the contrary.

A well-known motor car was designed by running the weakest parts to destruction and then increasing the factor of safety until the required length of service was obtained. The information that manufacturer has obtained by this method was costly at first, but that car has obtained a reputation for durability that has not been equaled.

EDITORIALS

The Shipping Board's Rules for Marine Machinery

IN OUR review of the year in the January seventh issue brief mention was made of the rules and regulations of the United States Shipping Board Emergency Fleet Corporation covering the building and inspection of the machinery used on board the ships made for and by the Fleet Corporation. Since then, Series One of the rules has come from the press and is now being distributed. It was necessary to formulate rules governing the allowances and tolerances for the great quantity and variety of mechanical equipment going into the enormous tonnage built and to be built by the Emergency Fleet Corporation, not only to get standardization, but to protect the investment and minimize troubles at sea. Our shipping will have enough to compete with without being burdened by the losses inevitable when ships are crippled.

When one looks casually at the little book of rules, seven by four inches, one hundred and forty-three pages, one finds it quite difficult to assess its value, to visualize all that was necessary to produce it. But if one will read over the names of the distinguished engineers who comprise the eleven committees which formulated the rules, if one will see them coming together at Philadelphia, sometimes at short notice, there agreeing upon the thousand and one differences in opinion, in shop practices, in experience—all to the end that not only should their rules and instruction produce the best and safest equipment, but permit of its production, delivery and installation in such expeditious manner that not an instant's delay would affect the delivery of the completed ship—one will get a conception of the import of the little green volume.

Now the Boiler Code was something like eleven years in the making, and it covers only some kinds of boilers. But it is an invaluable work and everybody knows it. The Emergency Fleet's rules were formulated in a matter of weeks and cover every apparatus aboard ship from propeller to boiler. Among the names in the book of rules will not be found that of the dynamic gentleman from Lowell who, as standardization engineer for the Shipping Board, directed the making of the rules. But John A. Stevens' name should be there, just as it is in the Boiler Code, which he with equal force worked so hard to formulate. No little credit is due the departmental engineers and chiefs of the Emergency Fleet Corporation who so thoroughly coöperated with Mr. Stevens and the several committeemen.

Of particular interest is the section of the rules devoted to refrigerating machinery. Probably no industry in engineering had so little standardization or more badly needed it than the refrigerating machinery industry. Yet the committee did a noteworthy work; it is complete, practicable and eminently fair. The personnel of the committee should be known: E. H. Oderman, chairman, Frick Company; James McNaught, consulting engineer, New York City; Louis Block, consulting engineer, New York City; F. M. Woodford, consulting engineer, New York City; R. A. Gulick, Brunswick Refrigerating Company, New Brunswick, N. J.; H. R. Fisher, York Manufacturing Company, York, Penn.; L. S. Morse, York Manufacturing Company. Frank Gentles and D. H. Scott were engineer and inspector respectively for the Fleet Corporation. If ever the American Society of Refrigerating Engineers wants to draft standards for the construction of its industry's machinery, it will find the Fleet Corporation's rules an invaluable guide.

The book of rules, known as Series One and open to revision as practice requires, is one of the good things in a mechanical way to come out of the war. The shop practices of the best manufacturers were thrown into the melting pot, and the most excellent and practicable poured into Series One.

The Electrical Study Course

IT IS a truism that success in any line of endeavor today, requires a better understanding of the underlying principles and a broader experience than ever before. Nowhere is this more true than in the modern power plant. The early power-plant engineer was to a large extent a mechanic backed up by strong muscles, a stout heart and a willingness to do hard work. In the small plant if he kept the steam up and the engine running when needed, and attended to the general mechanical needs out in the plant, he was a good engineer in the eyes of the owner. Consideration was rarely given to the cost of operation. In the larger plants there were one or more firemen whose highest qualification was the ability to shovel coal and keep the steam-gage hand at the required figure. How much coal they burned to accomplish this was a secondary consideration. The engineer's qualifications were judged by his ability to keep the engine running; "pounds of steam per kilowatt-hour" was a thing alien to the minds of both the plant manager and the engineer.

The day has gone when ability to shovel coal and keep the engine running is the only qualification the power-plant engineer requires. Not only must he know how to do this, but he must know how to do it most efficiently. Although he does not actually fire the boilers, he must know the most efficient way of doing it. He must be familiar with the heat value of fuels, the right amount of air for efficient combustion, temperature of flue gases and gas analysis, etc., so that he may instruct his firemen how to obtain the highest evaporation per pound of coal fired. In the engine room he must not only know how to keep the complicated multiplicity of machinery in good operating condition, but also how to produce a kilowatt-hour at the switchboard with a minimum steam consumption.

Along with the vast increases in the appurtenances in the steam end of the plant, have been added refrigerating equipment, ventilating and heating equipment and a vast array of electrical machinery. It is the engineer's job to see that this equipment is kept in efficient operating condition. To do this in some of the modern plants the chief engineer may have as many as one hundred and fifty men under him, or even a greater number. Thus he not only must be familiar with power-plant operation, but also must be an executive of no small ability.

Throughout this development in power-plant equipment, *Power* has endeavored to furnish those interested in power-plant operation the necessary information to assist in solving their problems. Among these problems none are larger than the electrical, for scarcely any part of a modern power plant can be considered without coming in contact with electrical devices. Among the many practical articles published in our reading columns on the installation, operation and maintenance of electrical equipment, The Electrical Study Course has appeared every other week for over two years. The purpose of this course is to give the reader who wishes a better knowledge of the fundamental principles of electricity, magnetism and electrical machinery, an opportunity to avail himself of a systematic course of study. How successful this course has been is indicated by the ever increasing demand for more of this material—a demand that has become so great that we have decided to publish lessons weekly until the course is completed. Therefore, starting this week, you will find The Electrical Study Course in each issue instead of every second week.

Light Curtailment and Accidents

THE statement that approximately twenty-five thousand persons are killed or permanently disabled, five hundred thousand seriously injured and one million slightly injured each year in this country is something that should be of serious moment to employers, even though human life has been one of the things held least dear the last four years. As pointed out in a paper, "Light Curtailment and Accidents," by R. E. Simpson, presented at the annual convention of the Illuminating Engineering Society, an abstract of which is published on page 144 of this issue, translating these figures into an economic loss, we have the appalling waste of what is equivalent to six hundred thousand employees working three hundred days per year.

That eighteen per cent. of this loss, or the services of one hundred and eight thousand men per year, is due to poor lighting should be, now that we are again turning our attention to peaceful pursuits, a very stimulating factor to our industries to use the best illumination practice available.

The inadequacy of illumination in our industries was further brought out by J. A. Sweet, in the discussion of the paper, in that probably less than five per cent. of them represent in their illumination a close approximation to the best practice, about twenty-five to forty-five per cent., although they have made a good beginning toward proper illumination, are still far short of what could be considered good practice, and the remaining fifty to sixty-six per cent. are grossly inadequate.

It has been estimated that proper illumination in our industries would result in an increase of fifteen per cent. in production. "This is equivalent to the production of an army of approximately one and a half million workers; an army that consumes neither food nor clothing nor wealth in any form; an army that produces without additional factory buildings or machinery or tools; an army that gives at least two-thirds of its wages to be divided between capital and labor."

Another economy that results from proper lighting is a decrease in spoilage due to faulty workmanship. This saving has been estimated at one hundred million dollars per year, or equivalent to the labor production of approximately one hundred thousand workers.

The indications are that competition in the future will be more keen than ever before, consequently every manufacturer will have to consider more closely means that will increase production or improve the quality or both, with little or no increase in cost. One of the most fruitful fields appears to be in furnishing the proper illumination. But this does not necessarily mean more light. Many of our industries have installed sufficient candlepower, but the way this has been applied it is far less effective than a considerably less value properly utilized. The time has long since passed when any old lamp equipped with any old shade installed in any old way constitutes good illuminating practice. Proper illumination consists in the selection of the lamp and shade best suited to each condition and maintaining it in good condition after being properly installed. The sooner this is recognized by plant managers the sooner we will begin to obtain correct illumination in our industries and eliminate some of the waste pointed out in the foregoing.

Among the stock instructions passed out in the early day to those who had to do with electric generators, etc., was: "Always keep one hand behind your back" (to avoid forming a short-circuit by a two-point contact). As electric equipment became more complex, necessitating the use of both hands, the rule had to be changed to "use both hands and your head." This new rule can be profitably applied to other work.

Cheap coal is not always cheap fuel because cheap coal usually contains a high percentage of ash, which necessitates frequent cleaning of fires, and this means frequent changes of firemen. A good fireman will not remain on a job that is practically a continuous performance of firing, leveling and cleaning out ashes. Changing firemen does not lead to economy.

It is asserted that the United States requires two hundred million piston rings annually, most of which are used for automobiles and airplanes—to say nothing of what might have happened if that $642,000,000 had gone into airplanes.

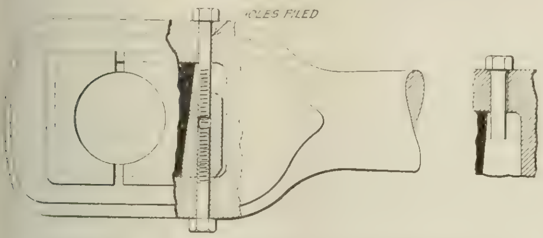
Esprit de corps is the French name for the impulse that keeps the whole engineroom force busy on Sundays, overhauling the machinery, without demanding pay for extra time.

If zoning, pooling and the avoidance of cross-hauling added to the efficiency and economy of our coal-distributing system in time of stress, why this haste to abandon them?

CORRESPONDENCE

Why Do Wedge Bolts Break?

A subject worthy of discussion in *Power* is, Why do wedge-adjusting bolts break? I have in two cases found that the wedge did not butt the rod end properly and this caused a partial shearing effect. The first case developed in a very slow-running four-valve engine when the steam pressure was increased from 65 to 100 pounds.



WEDGE HELD AWAY FROM ROD BY THE BOLTS

The illustration will explain the trouble. The draw bolts were a very good fit in the rod and when strain was applied the wedge stood away from the rod about sixteen-thousandths of an inch. Of course the pressure forced the wedge back where it belonged, but this put a strain on the bolts and sometimes the bottom bolt would break and again the top bolt would break. It was somewhat of a job to file the holes in the rod back so that the wedge would seat properly, but it was worth the candle.

The second case was that of the top bolt breaking under the head. In this case a condenser had been connected to the engine, as the steam pressure could not be raised and the engine was lagging. The second week after the new condenser was placed in operation, the top bolt broke under the head. A new bolt was put in, after about three hours' work and this bolt broke in the same place in less than one week. Our old machinist suggested that the hole in the rod be countersunk a little and a bolt made with a fillet under the head, as shown in the smaller section. This cured the trouble.

Without doubt poorly fitted boxes that play in all directions may cause the wedge bolts to break, and running a box so loose that it pounds will produce the same trouble. I never had a large wedge bolt (1¼ or 1½) break, though I have had several in operation. The ones referred to were ⅝- and ¾-in. bolts.

New York City. C. W. PETERS.

Control of Forced Draft

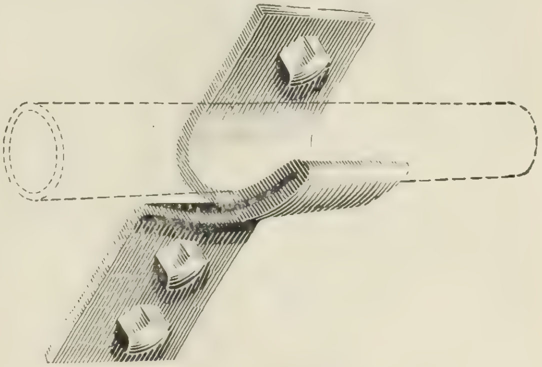
J. T. Sharp, Jr., described in the issue of Dec. 24, 1918, page 929, an ingenious automatic control for forced draft when using undergrate blowers. It has been my experience that the best method of operating turbo blowers is to carry a sufficient air pressure under the grate to maintain a pressure just a shade under that required to overcome the friction resistance of the fuel bed. This will give a slight vacuum or draft over the fuel bed, which will measure from 0.05 to 0.10 inch of water. Adjust the blower to give a pressure of from 0.40 to 0.45 in. of water and allow the natural draft to overcome the remaining part of the fuel-bed resistance. This is a balanced draft condition which will overcome back flashing through the firing doors. Minimum draft above the fire will prevent, to a large extent, the loss due to drawing in cold air through the open firing doors and also will cut down air infiltration through the setting. It is wise in any case to install draft gages, at least one in each ashpit and one in the combustion chamber, so that conditions may be checked at all times.

It may be possible that the back flashing when the fire-doors are opened is due to noncombustion of the volatile matter in the slack or dust. If the fire-doors are left ajar for a few minutes after firing, it is likely that this trouble will disappear, as the air drawing in over the fire takes care of these unburned gases. The Bureau of Mines recommends equal amounts of air over and under the grates for the average semi-bituminous coal. Leaving the fire-door ajar immediately after firing will usually furnish the extra quantity of air required for complete combustion. R. B. CLAPP.

Pittsburgh, Penn.

A Simple Pipe Bracket

The article on "Various Types of Pipe Hangers" appearing on pages 770 and 771 in the issue of Nov. 26, 1918, brings to mind the bracket shown in the illustration. It is made of a single piece of strap iron, is very easily fashioned and will carry pipes up to 6 in. in diameter. There appears to be no reason why it could not be used for larger sizes, but I have not seen it applied to such. WILLIAM H. WATSON.



A ONE-PIECE PIPE BRACKET

Morristown, Penn.

Column Blowoff Valve Leaks

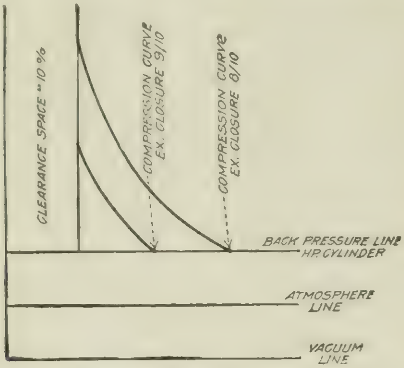
We had considerable trouble with the blowoff valve on the bottom of the gage-glass dripping constantly. We frequently renewed the valves, but they would not stay tight long. I extended the pipe from the bottom of the gage-glass and put the blowoff valve on the lower end of the pipe. This seems to protect the valve to some extent and prevents leakage. In that way the blowoff valve lasts considerably longer.

This is a simple suggestion, but it may help someone that is having similar trouble. R. A. WILLIAMS

Manassas, Va.

Unsymmetrical Indicator Diagrams

Referring again, if I may, to the subject of unsymmetrical indicator diagrams in answer to Mr. Hughes in the issue of Jan. 7, 1919, page 29, I submit the theoretical compression curves for a case where the compression begins at nine-tenths stroke and the other where it begins at eight-tenths stroke, the clearance space being 10 per cent., or equal to one-tenth of the volume of the piston displacement. The compression pressure from nine-tenths stroke is, of course, double because the steam entrapped is compressed into one-half the space. This may be taken as the original condition at both ends of the cylinder—referring to my letter in the issue of Dec. 10, 1918, page 856. If all the compression is thrown to one end of the cylinder, then the exhaust valve will close at eight-tenths stroke and the compression curve would correspond to the upper curve. The final pressure would be three times the original, because three volumes have been compressed into one. The measurement by planimeter of the large area is found to be about 50 per cent. greater than the smaller area doubled, for the two ends.


CLEARANCE SPACE = 10 %
COMPRESSION CURVE EX. CLOSURE 9/10
COMPRESSION CURVE EX. CLOSURE 8/10
BACK PRESSURE LINE H.P. CYLINDER
ATMOSPHERE LINE
VACUUM LINE

COMPRESSION CURVES FROM TWO DIFFERENT POINTS

It is obvious since the average pressure shown by the upper curve is greater and the distance traveled by the piston against compression in both cases is the same, whether all done at one end or divided, that the total resistance or compression effort is greater when all at one end.

The main point, however, is the broad principle that an indicator diagram from a given engine operating perhaps under unusual conditions "does not have to look like the picture in the book" to be the best one for that engine to produce. The final test is the operation or running of the engine—like the proverbial test of the pudding. My mode of procedure is to set valves to conform to the conventional as nearly as possible, and then modify the adjustment in such a way as to get the best operation under the given or average conditions. The final test on erecting a new engine or adjusting one should always be to slack back on the adjustment of the crank and crosshead pins and run the engine from no load to full load. If it does not operate reasonably quietly, it is not right either in design or adjustment. If the design is wrong for the operating conditions, as cited, the operation may in many cases be improved by so adjusting the valves as to counteract the structural defect. This in no way deprecates the use of the indicator because it is all the more necessary to use one in adjusting the engine in the same way later. J. LEWIS.

New York City.

Requirements of a Diesel Operator

In his letter appearing in *Power* of Jan. 7, Mr. Cooke falls into the all-too-common error of insisting that intelligence and not skill is the main requirement of a Diesel operator. I do not believe any manufacturer of steam engines would venture to suggest that the operating engineer need not be skilled. The corner grocer is intelligent, in the accepted meaning of this word; still, Mr. Cooke would probably insist that the operator of one of his engines be not only well-informed on current matters, as is the grocer, but also versed in the particulars of oil engines. If a man is well-versed in any line, it is usual to term him skillful in that line.

Mr. Cooke perhaps intends to convey the idea that there is no special mystery about the functioning of a Diesel engine and that any good steam engineer can, after some experience, successfully cope with all operating difficulties that arise. If this is the idea he intended to convey, he is undoubtedly correct in his argument. Any man who is capable of meeting the many perplexing problems that arise in a modern steam plant possesses enough intelligence and, in all probability, enough mechanical skill to operate any oil engine after some training.

The one great obstacle that the steam engineer must overcome is his natural aversion to any form of internal-combustion engine. This feeling is the result of his belief that the peculiarities of the oil engine are baffling. The steam operator is accustomed to having the causes of practically all ordinary plant defects perfectly transparent. If the problem is baffling, the steam plant usually continues to function, even though at decreased power or increased cost. On the other hand, the Diesel engine, as the editor expressed it, must operate economically or not at all.

The operator is seldom given time to investigate the reason for the operating defect. He must be able to decide immediately on the proper procedure to follow in correcting the fault. For instance, if the engine slows down, one of a score of things may be the cause. The fuel supply may be gone; the fuel line clogged; the fuel oil mixed with water; the fuel-pump valves leaking; the fuel valve wedged open; the injection-air pressure too low, due to one of a dozen probable reasons; the piston rings broken, destroying the compression; the lubrication of the cylinder defective; the cooling-water supply inadequate to cool the cylinder thoroughly; or a number of other things not enumerated. The majority of these defects may exist without the fact being at once apparent. To the steam engineer this condition is baffling and he usually ends up by unjustly condemning the engine.

The writer has met many steam engineers who have tried to operate oil engines, and in most cases they regard the oil engine as a sort of magic worker. They see its hands are open, but are positive it will pull a white rabbit or at least some kind of jinx out of its overalls pocket. If the steam operator will put aside his personal objections, there is no reason why, with some months of training, he should not qualify as a Diesel operator.

Mr. Cooke may have intended to convey this idea of the adaptabilty of the steam engineer to Diesel operation. However, his mention of the Ford engine to prove that skilled attention is not essential would seem to indicate a belief that any man of intelligence, but without mechanical skill, can be immediately transformed into a Diesel operator. Let us consider the Ford. This engine rates about 20 hp., but with the usual road conditions a Ford owner runs his machine at around 7 hp. output. The engine is then running at some 30 per cent. of its rating, and the wear is correspondingly low. Furthermore, it is the exception rather than the rule for a Ford to run more than two or three hours without a stop. In fact, most owners seldom make runs extending over an hour's time. Even though the load factor is under 50 per cent. and the period of operation less than 10 per cent., the Ford engine will wear out. Thirty thousand miles is much higher than the average Ford engine covers before it is ready for the junk pile or second-hand dealer. At 20 miles per hour this represents 1500 hours of operation. Would Mr. Cooke be satisfied with a 1500-hour life for the McIntosh & Seymour Diesel? To the contrary, it has been stated by the McIntosh & Seymour Corporation that their engine needs no important adjustment of bearings, etc., inside of 10,000 hours of service. No reasonable person will deny that a considerable part of the rapid depreciation of the automobile is due to the lack of skill on the part of automobile mechanics.

The Diesel engine does not enjoy the popularity in America that is due it. This can, in a large measure, be attributed to manufacturers' statements of the lack of skilled attention required. The purchaser invests and, with the glowing statements of the builder in mind, forthwith employs an attendant who could not run a sawmill steam engine, but who is undoubtedly intelligent—at least, he votes.

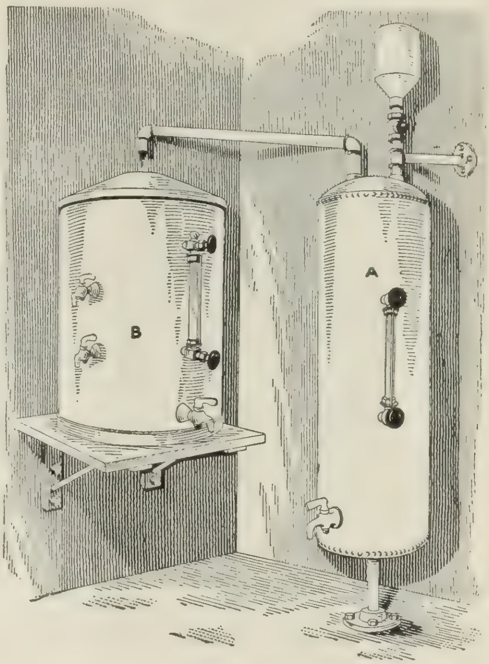
The writer has never been able to understand why the Diesel builder lays so much stress on the claim that skilled help is not necessary. Even with high-priced labor the Diesel is economical. In a Texas Diesel plant of 1500-hp. capacity a high-priced chief, who is a machinist, is employed. While the watch engineers' pay is above the normal rate, still the total cost per kilowatt output, including a 15 per cent. fixed charge on plant cost, is under one cent. This is lower than the cost at a Texas steam turbine plant of over 10,000-kw. capacity using 8-cent gas as fuel and with only a 12 per cent. fixed charge.

The successful Diesel operator must be, above all, a machinist. If the chief engineer of a plant does not possess this requisite, then a machinist must be employed, or the plant faces rapid deterioration. The Diesel is the most economical prime mover in existence at present and is altogether a most satisfactory unit. The writer has operated several makes and investigated a number of plants, and without exception the successful plant has a machinist in its organization.

Philadelphia, Penn. E. E. Snow.

An Easily Made Oil Filter

A short time ago, while visiting a neighboring power plant, I saw an oil filter that is a little out of the ordinary and that can be easily made. There were only two 50-kw. units in the plant, each of which had a gravity oiling system, with a small tank placed above the highest bearings. All waste oil was drained off into a bucket and emptied by hand into the filter, made as shown in the illustration.



OIL-WASHING TANK RELIEVES FILTERS

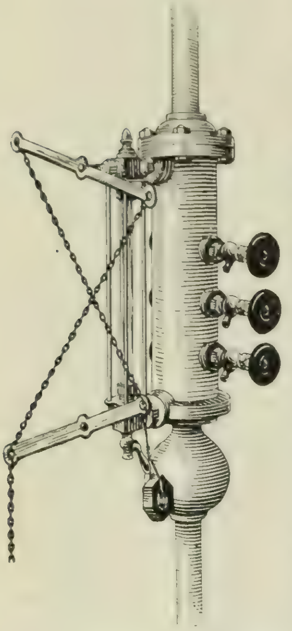
Tank *A* was a 30-gallon range boiler and *B* is a small oil filter. Tank *A* is filled about half full of water. The used oil is poured into the funnel at the top, which holds about three gallons, and flows slowly down the pipe extending inside of the tank to the bottom similar to the cold-water pipe in a range boiler. The cock is partly closed to regulate the flow. The oil then passes up through the water to the overflow pipe at the top to the tank, during which time the water washes out the foreign matter and cleanses the oil. The drain-cock at the bottom of tank *A* is opened at intervals and the sediment flushed off and clean water added at the top. It is necessary to clean the second filter only at long intervals and clean oil is assured with little attention. It could be improved by means of pumps to handle the oil automatically, but the amount of oil used is so small that it can be done by hand in a few minutes. J. C. Hawkins.

Hyattsville, Md.

Boiler Tubes Were Burned

I had occasion recently to accompany a boiler inspector to a plant containing a 350-hp. water-tube two-drum curved-tube-type boiler, and what we found there was interesting.

The first nest of four rows of tubes were almost without exception burned away, beginning a few inches above the ashes that lay on the lower drum and upward for four or five feet. This, of course, caused the baffle walls to collapse and expose the tubes of the second pass, and most of these tubes were also burned out or twisted out of place. All drums were found intact. The lower drum had a heavy covering of ashes, which no doubt saved it from being burned, and the upper one was quite a distance from the fire. Inspection was continued to the water column, where a dangerously rigged-up affair was found. The gage glass valves were originally operated by arms and chains, from the floor, but the chain from the opening arm of the water valve was missing and instead there was a light metal weight hung on it, not heavy enough to overcome the friction of the packing. The other, or closing, arm had a chain hanging to within reaching distance of the floor.



CHAIN CONNECTION AS FOUND

The chain connections between the steam and water valves were crossed as shown in the illustration, and obviously, when the floor chain was pulled the water was shut off and the steam connection opened, or if the weights happened to open the water connection, the steam connection was closed. The water connection was found closed and was probably in that position when the "burnup" occurred. J. M. Reeves.

Mercedes, Tex.

Chemical and Physical Control of Boiler Operation

As might be expected from anything written by Mr. Uehling, the article on "The Chemical and Physical Control of Boiler Operation," printed in your issue of Jan. 7, is a valuable contribution to the literature on coal conservation. However, we think that Mr. Uehling has devoted himself to chemical and physical control so long that he unconsciously overlooks or rather slights mechanical control.

For example, he states regarding weighing of coal to boiler for comparison of readings of hot water or steam-flow meters: "The results cannot be calculated oftener than once a day and generally once a week is considered sufficient for a control over the operation of a boiler plant." Automatic boiler scales give a continuous record of the coal delivered to each individual boiler and hourly comparisons can be made, if desirable, although comparisons of consumption on different shifts are more customary. Mr. Uehling is evidently comparing obsolescent hand-weighing methods with CO_2 recorders, etc.

Again, he says: "The coal weigher cannot discriminate between coal, ash and moisture and since these constituents are never constant and frequently vary 5 per cent. or more in successive shipments, and since the heat value of the fuel depends on its purity, the calculated results will be that much in error." This is true, but he ignores the fact that the greater accuracy of automatic coal scales (one-half of one per cent.) over CO_2 recorders, draft gages, pyrometers, etc., probably more than compensates for the variables mentioned.

He states further: "The mechanical control has another and even more serious shortcoming in that it gives absolutely no clue as to why the plant as a whole is operating more or less wastefully." He ignores the fact that CO_2 recorders, pyrometers or draft gages by no means cover the entire field of boiler efficiency. For example, the boiler may be scaly or the quality of the coal may be poor, without their indicating same. A comparison of coal consumed with water evaporated or steam pressure obtained indicates if anything is wrong.

When Mr. Uehling in contrasting the two methods of control—mechanical and physical and chemical—says that "either method is better than no control at all, and neither method is by itself adequate to produce maximum economic results," he states the full truth. There is room for both mechanical and chemical and physical control of boiler-room operation and nothing short of both is control. F. Odone,

Passaic, N. J. Richardson Scale Co.

Current in the Center Conductor of a Two-Phase Three-Wire System

On page 31 of the Jan. 7 issue of *Power*, "Inquiries of General Interest," answering the question by W. D. T. in regard to "Relations of Currents in A. C. Systems," I notice what appears to be a typographical error.

In the section of the answer referring to currents in a balanced two-phase three-wire system the current in the two outside wires is given as $I_c = I_b$, I_b being current per phase in an equivalent two-phase four-wire system. The current in the common wire is given as $I_c = \sqrt{2I_b}$; this expression should read $I_c = \sqrt{2}\,I_b$. That is, I_b should not be under the radical, but should be multiplied by $\sqrt{2}$ (1.414). In other words, the current in the center leg of a balanced two-phase three-wire system is equal to the current, in amperes, in one of the outside legs times the square root of two.

Newark, N. J. W. E. Clemson.

INQUIRIES OF GENERAL INTEREST

Depolarized Belts—Pumps, driven through depolarized belts, for transmitting gasoline, have been ordered for one of our plants. How is depolarization of belts accomplished?
S. R.

Belts running at high speeds in dry places take on a high static electrical charge. The sparks caused by the discharge from such belts become very dangerous where gasoline fumes or other highly explosive fumes are present. The usual method of overcoming static is to place one or more metal combs in close proximity to the belt and connect them to ground. Pieces of small chain or wire may be used for the same purpose. Driving these pumps direct would seem to be a much better practice, as this would eliminate any trouble that might arise from the use of a belt.

Varying Speed of a Compound Motor—Can the speed of a compound-wound motor be adjusted by the use of a variable resistance connected in series with the shunt-field winding as in a shunt-wound motor?
W. N. C.

The speed of a compound motor cannot be adjusted by introducing a variable resistance in the shunt-field winding, and operate as a compound machine, as with a shunt motor. This is due to the ampere-turns of the series winding becoming more effective as the ampere-turns of the shunt winding is reduced. Where a drive requires a compound motor during the starting period and shunt-field control after, the series winding is cut out of circuit before introducing resistance into the shunt-field circuit. Such conditions are found in elevator and printing-press drives, etc.

Charge for Steam with Increased Price of Coal—The cost of operating a boiler plant to supply ourselves and a tenant with steam for heating buildings during last winter was \$18,674.55 for coal at \$9.50 per ton and \$3948.11 for wages, supplies, repairs, water and removal of ashes. What should the tenant be charged per 1000 lb. of steam in a new contract based on \$9.50 per ton for coal so the price will be equivalent to that charged by a former contract of \$0.50 per 1000 lb. when coal was \$4.25 per ton?
S. T.

In addition to the operating expenses mentioned, an estimate should include overhead charges such as ground rent, interest on investment in boiler and equipment, allowance for depreciation amounting to about 7 per cent. per annum, taxes, insurance, cost of supervision and reasonable profit, and the total charges applicable to each period should be considered. But if such data are not available, and it is conceded that an operating expense of \$3948.11 and an overhead of \$3000 are applicable to both periods under consideration, then during the last season the total cost may be considered to be \$18,674.55 + \$3948.11 + \$3000 = \$25,622.66 and the proportion chargeable to coal was 18,674.55 × 100 ÷ 25,622.66 = 72.8 per cent. As this is based on coal costing \$9.50 per ton with other expenses the same as during the first period, a charge of \$0.50 per 1000 lb. of steam based on coal costing \$4.25 per ton would be at a loss of one-half of 72.8 per cent. or 36.4 per cent., and the rate based on coal costing \$9.50 per ton should be \$0.50 ÷ (100 − 36.4) = $78\frac{6}{10}$ cents per 1000 lb. of steam.

Improvement of Draft by Cleaning Chimney Connection—A boiler fireman was informed by his superior that no improvement of draft was to be obtained by cleaning out the smoke connections to the chimney which had become filled about one-third full of soot. What is the explanation of this, if true?
B. F. G.

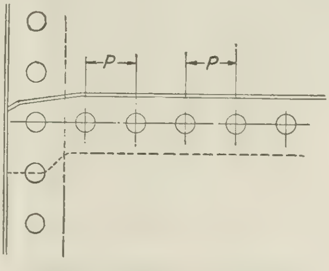
For a given force of draft and given size of chimney flue, the volume of furnace gases that can be carried off depends on the least cross-sectional area of smoke-pipe connection and the smoothness of the passages for the gases from the boiler to the chimney. Sharp corners and short bends cause swirls and eddies that give rise to soot deposits which smooth out the channel and usually result in so much higher average velocity that there is a greater volume of gases discharged with the reduced but modified cross-sectional area. Generally speaking, removal of the soot deposits will not improve the volume of draft, unless it results in enlarging the smallest cross-sectional area for passage of the furnace gases. However, no serious error is made by removal of a greater quantity of soot for, in very short time, deposits again form in best arrangement for maximum draft.

Objections to Excessive Blowdown of Pop Valve—Why is it more objectionable to have a boiler safety valve blowdown 10 lb. than 4 lb. below the pressure for which the valve is set to pop?
R. W.

The greater the blowdown the lower must be the available working pressure below the safe working pressure for the boiler. In addition to this disadvantage in operation, the broader the variation of pressure on the boiler the greater the injury to the joints and material in the nature of a racking effect. The amount of blowdown allowable should be considered with reference to the pop pressure. It is considered good practice for the valve to be adjusted to close after blowing down not more than 4 lb. on boilers carrying 100 lb. per sq.in. gage; 6 lb. on boilers carrying 100 to 200 lb.; and not more than 8 lb. on boilers carrying over 200 lb. per sq.in. gage.

Safe Working Pressure for Air Tank—What is the safe working pressure for an air tank 42 in. diameter, made of $\frac{1}{4}$-in. steel of 55,000 lb. T. S. with single-riveted lap seams, diameter of rivet holes and rivets after driving $\frac{11}{16}$ in. and pitch of rivets $1\frac{3}{4}$ in.?
G. N. H.

For thickness of plate $\frac{1}{4}$ in. = 0.25 in.; pitch of rivets $1\frac{3}{4}$ in. = 1.75 in.; diameter of rivet holes and rivets after driving, $\frac{11}{16}$ in. = 0.6875 in., giving cross-sectional area of rivet = 0.6875 × 0.6875 × 0.7854 = 0.3712 sq.in.; and allowing a shearing strength of rivets = 44,000 lb. per sq.in. of cross-section and 95,000 lb. crushing strength of plate, for a length of the shell equal to the pitch *P* in the sketch there would be:



SINGLE-RIVETED LAP JOINT

(A) Strength of solid plate = 1.75 × 0.25 × 55,000 = 24,062 lb.

(B) Strength of plate between rivet holes = (1.75 − 0.6875) 0.25 × 55,000 = 14,609 lb.

(C) Shearing strength of one rivet in single shear = 1 × 44,000 × 0.3712 = 16,332 lb.

(D) Crushing strength in front of one rivet = 0.6875 × 0.25 × 95,000 = 16,328 lb.

The strength of the longitudinal joint would depend on consideration (B) and the efficiency of joint would be

$$\frac{(B)}{(A)} = \frac{14,609}{24,062} = 0.607,$$

or 60.7 per cent.; and with a factor of safety of 5 the maximum safe working pressure would be

$$\frac{55,000 \times 0.25 \times 0.607}{(42 \div 2)5} = 79.4 \text{ lb. per square inch.}$$

Light Curtailment and Accidents[*]

By R. E. SIMPSON

THE significance of accident prevention will be readily appreciated if we consider the effect of accidents in terms of time lost. From the published statistics of a number of states, together with conservative estimates for the remainder, we find that approximately 25,000 persons are killed or permanently disabled, 500,000 seriously injured and 1,000,000 slightly injured each year. Translating these figures by means of the accident severity rates, we have a total of 180,000,000 days of lost time. This is equivalent to the loss of the services of 600,000 men for a full year of 300 working days. This economic loss is distributed over the entire country during a period of one year, and for that reason its effects are not so keenly felt or its importance recognized.

It is apparent we have here an important factor touching on the supply of labor, and anything that can be done to curtail this economic loss is worthy of careful consideration. There is a certain percentage of unavoidable accidents; that is, man's prevision is unable to cope with unknown factors, and this is especially true of pioneer work. The best that can done is to profit by experience, and endeavor to prevent the knowledge and experience thus gained from lagging behind practice. A large percentage of accidents may be classed as avoidable in the sense that the application of mechanical safeguards and the observance of safety rules will prevent them. Anything in the form of a practicable guard, of safety education, or of safety regulations that will protect the worker from injury should be welcomed by the plant manager today. Past investigations have indicated various influences on the causation of accidents, and prominent among these is industrial lighting.

PERCENTAGE OF ACCIDENTS DUE TO FAULTY ILLUMINATION

A survey of 91,000 accidents from the records of The Travelers Insurance Co. for the year 1910 showed that 23.8 per cent. were due to improper or inadequate illumination. Bearing in mind the progress in the art of illumination during the past eight years, it is hardly possible that this percentage prevails today. New factories are lighted by up-to-date equipment, while many old plants have had their lighting systems brought into conformity with modern practice. These are steps in the right direction and are bound to be reflected in the accident rate. Offsetting this, to a certain extent, is the practice of many plant managers of substituting high-efficiency lamps, both gas and electric, for low-efficiency lamps, without providing adequate reflector protection. Notwithstanding the vast amount of expert advice that has appeared in the technical journals devoted to specific industries, there are literally thousands of plants that have not profited by this advice. The directing personnel of these plants, from managers to subforemen, do not seem to appreciate the difference between light and illumination, between a reflector and a wire guard.

There is some foundation, however, for assuming that 18 per cent. of our industrial accidents are due to defects in the lighting installation. On that basis the services of 108,000 men for one year are lost annually, because the illumination provided is not adequate for the safety of the workers. That this condition should exist year after year is all the more reprehensible because of the fact that the remedy is so easily applied and has beneficial results in many ways other than in the element of safety involved. Accidents caused by carelessness, inattention or ignorance can be eliminated only by a long-continued, painstaking educational campaign often involving a change in long-established habits. The elimination of accidents due to inadequate or improper lighting is simply a matter of purchasing approved equipment and installing it under competent direction. In fact, it seems proper to include illumination in the list of mechanical safeguards, for the reason that the lamps and reflectors provide the guard—illumination—to point out the hazard, just as effectively as a railing points out the danger of and provides protection against the hazard of a revolving flywheel. The sum involved is insignificant when compared with the accident claims, or the lost profit on the product of the labor, or the value of the product itself.

Anyone who makes an extended survey of the lighting conditions of our industries will inevitably be impressed by the much larger percentage of *improper* installations when compared with the *inadequate* installations. This is due primarily to the praiseworthy, but none the less ill-advised, attempts to better the plant illumination on the basis solely of providing a greater candlepower output. The questions of distribution, diffusion and absence of glare are either not fully appreciated or are entirely unknown, and therefore do not receive proper consideration.

COAL SAVING BY CURTAILMENT OF INDUSTRIAL LIGHTING NEGLIGIBLE

The saving in coal by curtailment of industrial lighting is negligible when compared with the ultimate economic loss. For example, if the full year's labor of the 108,000 men that is lost annually, due to poor illumination, could be saved and applied to coal mining, 130,000,000 more tons of coal could be produced. To provide ample illumination for the safety of all these workers, ten hours a day for a full year, would require less than 10,000 tons of coal. We may convert this fact into a more detailed and concrete form by saying that a 25-watt lamp burning ten hours a day will provide adequate illumination on a stairway for one year by the use of one-eighth of a ton of coal. By dispensing with the lamp one-eighth of a ton of coal will be saved, but if during the year one accident occurs involving the loss of only one day's time the economic loss from a coal-producing standpoint would be sufficient to operate the lamp 32 years.

This brings us up to the point of considering the effect of diminished lighting at places where such reduction is almost invariably found. Stairways, elevated gangways, passageways and storage spaces are generally inadequately lighted and are the first to suffer from a policy of light curtailment. The hazards associated with these poorly lighted sections of our industrial plants have been portrayed many times. Confirmation of these hazards has been given by the report of the British government survey of industrial accidents showing that 40 per cent. more men are injured from falling and stumbling in the winter months than in the summer months. This is exclusive of street slipping accidents. The physical condition of the stairways and passageways is the same for both periods, the sole difference being in the illumination.

POOR ILLUMINATION IN STORAGE PLACES

Many accidents occur in storage places due to inadequate illumination, but this fact is not often brought out in the reports. Raw material and finished product are often piled in uneven tiers, and these fall over at inopportune moments. Carelessness is very often the contributing cause, but in many cases a conscientious worker will pile material unevenly simply because the illumination is not sufficient to show him the tier is out of alignment.

Even the supposedly well-lighted working spaces in some shops are not immune from accidents. A certain work bench was well illuminated by local lights with proper reflectors, but the bench cast a shadow on the floor, while the general illumination was not sufficient to offset the shadow. There followed a sequence of accidents due to the toppling over of partly finished work piled in the shadow. With a higher intensity of general illumination accidents of this type were largely eliminated. Passageways that are traversed infrequently hardly justify the continual use of an illuminant, unless there is exposure to moving machinery or other hazards. Irrespective of the danger element all passageways should have lighting units so installed that they can be turned on and off at either end.

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[*] Abstract from a paper presented at the 12th annual convention of the Illuminating Engineering Society, New York City, Oct. 10, 1918.

A method is open to plant managers by which, at the same time, coal will be saved, better illumination provided and accident hazards reduced. It consists in the universal use of reflectors. Every plant manager (as part of his lighting policy) should adopt the principle of a proper reflector for every lamp. In the field of general illumination, the use of unshaded lamps, in connection with naturally dark walls and ceilings, or with white walls and ceilings that have become dirty, is not only wasteful and inefficient, but also increases the accident hazard from bright light sources. Proper reflectors would bring this wasted light under control, and at the same time reduce the accident hazard. In a limited number of cases smaller lamps could be substituted and still ample illumination would be provided; but for the most part reflectors should be used with the lamps now installed to bring about a much needed improvement.

In the field of local lighting there is much more room for saving and improvement. There are thousands of 120-watt carbon lamps, and many more thousands of 60-watt carbon lamps, used for local lighting about machines. It is the exception rather than the rule to find these lamps equipped with reflectors. Wire guards are more popular. For purposes of illumination a 15-watt or 25-watt tungsten-filament lamp with proper reflector would prove adequate. The question of serviceableness or of breakage of this lamp over the carbon lamp is dependent on local conditions. The recent agreement between lamp manufacturers and the Fuel Administration insures a reduction in the use of carbon lamps. In enforcing this policy lamp users should be warned against employing tungsten-filament lamps without reflectors. Exposure to the high intrinsic brilliancy of the tungsten filament involves a greater degree of vision impairment than with the carbon lamp. Wire guards will not serve, for although they protect the lamp from breakage to a certain extent, they afford no protection to the eye. The lamp can be replaced for twenty-five cents, but the eye—vision—infinitely more valuable, cannot be replaced at any price.

During a recent inspection a workman at a stamping press was noticed persistently standing at one side of his machine. In answer to inquiries the workman stated that he could not see unless he moved to the side and closer to the lamp; and he also stated that he was going to get a "big tungsten lamp." He was working on large tinned sheets, and while standing in front of his machine a dazzling reflection was directed toward his eyes. A simple adjustment of his local light changed the angle of incidence and reflected rays and thus removed the trouble.

This incident is more or less typical. There is so much unintelligent use of light in the form of unshaded or improperly placed lamps that we are fast approaching the state of being a nation of eyeglass wearers. An important remedial step will be taken when we whole-heartedly get behind the movement of "a proper reflector for every lamp."

Chicago Section A. S. M. E. Welcomes Secretary Rice

On Monday evening, Jan. 13, at the Engineers' Club, the Chicago Section of the American Society of Mechanical Engineers held a real get-together meeting. "Know each other better" was the slogan. Solo selections and "mob" singing helped to let down the bars and open the way to a sociable evening. Calvin W. Rice, the national secretary, was present to receive constructive suggestions on how to improve the society and incidentally to tell of the big things now under way or in contemplation that should render exceptional service to members and raise the profession to its proper plane of usefulness and responsibility in public affairs.

C. E. Lord, chairman of the Chicago Section, presided. His opening remarks showed that coöperation was the spirit of the day. The activities of the war had reacted on the country and made evident the necessity of coöperation. Engineers in particular were affected by the movement and the speaker referred to the efforts now being made by the four big national societies through committees on development and the Engineering Council to broaden the aims and the scope of the work being done.

At the annual meeting three subcommittees had been appointed: One to investigate the relations of the engineer to his work; the second, his relations with the community; and the third, the relations of the mechanical engineer to other engineers. These committees were coöperating, interchanging ideas and would have some definite suggestions to submit at the spring meeting. There was also a movement toward consolidation of engineering associations and suggestions made during the evening or later in writing would be given serious attention. The path should be blazed by coöperation among the local branches of the various engineering associations. In Chicago it was the hope to soon hold a joint meeting of the mechanical, electrical, mining and civil engineers.

In the discussion following it was pointed out that unsociability stood in the way of engineers getting anywhere. Technical training had stood between them and their opportunities. It should be an attribute instead of all. The engineer must be sociable, and it would seem that one of the primary duties of the local committee was to make engineers come to meetings and enjoy themselves.

As an introduction to telling what the society is doing and has in contemplation, Calvin W. Rice wanted the local section to think of him as a man familiar with the West from years of varied engineering experience in that section of the country. In his work in New York he was constantly thinking of the members in the West and trying to bring the society closer to them. One of the recent big things was the purchase of the *Engineering Index*. Eleven hundred papers would be reviewed and in addition to the index, abstracts of leading articles would continue. It was the object to make the *Journal* under the new name of *Mechanical Engineering* so readable and useful that no self-respecting engineer could be without it. Subscriptions were to be taken outside the society and the circulation increased so that the advertising rates could be raised to provide more money for the broadening work of the society. The boiler code had cost $12,000. There were plans for weekly publication of the *Journal*.

It had been a dream of the secretary to reduce the dues to $5 following the plan of the physicians, who had a membership of 86,000. To mount to the same plane as this profession, the engineers must undertake public service with no hope of reward. Statistics were given to show what the doctors and lawyers were doing to keep their professions clean. Engineers might well follow suit. They must take part in civic and national affairs, carrying out all forward movements of the day that belong to them. Money and time must be spent to render this service without becoming enmeshed in politics. Engineers should participate in matters of interest in the community. They should have papers on the subject, discuss it and, when a decision had been reached, see that the city employed the right men to do the work and paid the right price for it. In Washington the society was about to open an office to keep members posted on national affairs.

Efforts are being made to enhance the status of the sections, so that papers read there would have attention from the publication committee equal to that given papers for the spring or annual meetings. The employment bureau was well organized and active, costing about $10,000 per year. It had been coöperating to good advantage with the Department of Labor. There had been no extra charge to members and there was the free service of the library.

It had been the speaker's desire to see Chicago provided with a combined engineering building and club. It would require coöperation between all engineering societies in the city and the services of a competent secretary. The New York building was now clear of debt, and one of the possibilities was to mortgage it to provide a loan to put up the Chicago building.

Professor Green, chairman of the Research Committee, enumerated some of the things in which it was the wish all should take a part. Reference was made to the experimental work being done in the laboratories of the various universities, technical schools and industrial concerns. Much of it was needless duplication and a waste of effort that might be eliminated if each knew what the others were doing. It was the plan to have a subcommittee in this section of the country that would be notified by the various members of the starting of some important work. The information would be passed on to the research committee, acting as a clearing house, and published in the *Journal*. In this way the profession would know what was being done and duplication could be avoided. When available, the results of the work also would be published. In addition it was the committee's desire to know what could be done in the Chicago district, so that it would make it possible to bring together the man who could do something and the concern that wanted something done. By clearing through the committee it would not be difficult to accomplish. Another advantage contemplated was the free preparation by the library of bibliographs on certain subjects requested by the members. Announcement would be made in the *Journal* that these bibliographs were being prepared so that others interested might obtain the benefit of the work.

B. A. Gayman, of the Link-Belt Co., was pleased to see the expansion under way. He was tired of the old cry of having something done for the local section instead of doing something for others.

Professor Gebhardt, of Armour Institute, had been impressed with the needless duplication of tests in the various engineering and industrial laboratories. Preliminary notices of tests would prevent this repetition. Armour for one would be glad to coöperate and give out for publication whatever useful information it might have.

What the Government is doing to place returning engineers was explained by Mr. Litchfield, a representative of the Department of Labor. A system of analysis and classification had been developed that would fit the man to the job, and the establishment of clearing zones would help to locate the engineers where their services were most needed. A clearing zone was already in operation in New York City and Mr. Litchfield was now organizing one in Chicago. The coöperation and assistance that had been given him by the various engineering societies had been highly appreciated.

Bituminous Coal Production by Months in 1918 and 1917

The estimates of bituminous coal production in the United States by months during 1918 and furnished to the United States Fuel Administration by the Geological Survey, including lignite and coal made into coke, compared with the corresponding months of 1917, show an increase of 34,092,437 net tons for the twelve months. The figures by months are as follows:

Months	1917 Net Tons	1918 Net Tons
January	47,967,354	42,607,206
February	41,352,711	44,384,937
March	47,868,652	48,631,115
April	41.854.320	46,590,570
May	47.086.452	50,927,195
June	46,824,646	51,758,214
July	46.291.572	55,587,312
August	47,372,226	55,732,092
September	45.107.956	51,757,334
October	48.337.726	52.885.513
November	47,689.801	44,386,987
December	44,037.147	40,634,525
Total	551.790.563	585,883,000

According to information collated by L. C. Harvey it appears that the quantities of pulverized coal used in the United States annually in various manufactures are as follows: In the cement industry, 6,000,000 tons; in the steel and iron industry, 2,000,000 tons; in the production of copper, 1,500,000 tons, and in the generation of power, 100,000 to 200,000 tons. To attain success the coal must be dried, crushed and pulverized until 95 per cent. will pass through a 100-mesh sieve, having 10,000 openings to the square inch. A cubic inch will contain over 200,000,000 particles, none of which will be greater than one-hundredth of an inch cube, and a large percentage less than one six-hundredth of an inch cube.

Rate of Coal Consumption in Electric Generating Stations

The Hydro-Electric Power Commission of Ontario, Canada, has published an interesting report on the rate of coal consumption in various electric generating stations and industrial establishments in the United States and Canada. The data were selected from such electric-power stations as use coal for fuel and which use it entirely for generating steam. All stations which use wood, oil, producer gas or any other fuel than coal, whether in part or not, and all stations acting as auxiliaries or stand-by plants in connection with power production by other means were disregarded.

As a result of numerous inquiries, replies were received from 73 stations, 50 per cent. of which were representative stations ranging in capacity from 150 kw. to 150,000 kw. The data, almost without exception, are from the averages of operation for the past five years. For convenience, the stations were divided into classes, according to size, as follows:

Class	Capacity in Kilowatts
A	Up to 1,000
B	1,001 to 5,000
C	5,001 to 10,000
D	10,001 to 50,000
E	50,001 to 100,000
F	Above 100,000

Among the interesting figures given in the report are found the following averages for the several classes of stations:

Class	Station Capacity Kw	Station Capacity Hp.	Coal Consumption Pounds Per Kw.-Hr.	Coal Consumption Pounds Per Hp.-Hr	Coal Consumption Tons Per Kw.-Yr.	Coal Consumption Tons Per Hp.-Yr	B.t.u Per Pound	Load Factor, Per Cent	Efficiency Per Cent
A	650	870	7.65	5.70	34.60	25.10	12.500	29.3	3.5
B	2,980	4,000	4.30	3.20	19.00	14.00	12,900	34.2	6.2
C	7,230	9,700	4.07	3.04	17.80	13.30	11,900	31.7	7.0
D	24,600	33,000	2.91	2.17	12.75	9.52	13,600	36.0	6.6
E	96,000	128,800	2.01	1.50	8.80	6.57	14,000	36.9	12.1
F	149,000	199,500	1.92	1.43	8.40	6.26	13,500	44.7	13.1
Average	46,740	62,600	3.81	2.84	16.90	12.46	13,600	35.5	8.4

The efficiency in the foregoing table is the efficiency of conversion of the heat energy in the coal to the electric energy at the switchboard. The heat value of the coal is found by taking the heat value for each station, multiplying it by the average pounds of coal used per year by the station, adding the products for any one class and dividing the sum by the total weight of coal burned per year by the plants in that class.

A serviceable floor paint may be made by adding to one gallon of white-lead paint of the desired shade one-half pound of litharge which has been worked out smooth with a little of the paint. Mix only as wanted.

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DURING THE RECENT HARBOR STRIKE IN NEW YORK THE BOATS OF THE MUNICIPAL FERRY TO STATEN ISLAND WERE MANNED BY MEMBERS OF THE POLICE FORCE

Fires Caused by Chimney Sparks

By Chesla C. Sherlock

Sparks falling upon the property of others are frequently the direct cause of loss by fire, and it is naturally necessary to determine whether the owner or operator of the power plant is liable for the damage.

It is a fundamental proposition of the common law that the owner of a smoke-stack or chimney must exercise ordinary care in its erection, maintenance and operation in order to escape liability for any fires caused by sparks falling from it. The theory upon which the owner of the chimney is made a defendant is that he has been guilty of negligence in failing to exercise this ordinary care imposed upon him by the common law. Unless the party damaged can show affirmatively that there has been a breach of duty or negligence on the part of the owner of the smoke-stack, his cause for damages must necessarily fail.

The owner of a smoke-stack is not a guarantor to the community against fire that may arise from sparks falling from his chimney. But, says the law, he must do all that an ordinarily prudent person can, to prevent damage and loss to the property of others in the vicinity. He must build his chimney as well as he can; he must maintain it in the manner suggesting itself to ordinarily prudent men and he must use it in a manner consistent with these tests. Otherwise the owner has not exercised ordinary care in its maintenance. The overwhelming rule of authority is that the owner is not liable for a fire set by sparks from a chimney, unless the element of negligence is clearly established by proof. The liability, therefore, cannot be said to be absolute, and the great majority of these decisions have freed the chimney owner from any liability whatever, because negligence could not be proved, or it was shown, on the other hand, that he had exercised the care and caution of an ordinarily prudent man, with knowledge of the business and existing conditions.

SOME RECENT DECISIONS RENDERED BY THE COURTS OF DIFFERENT STATES

In a Maine case the owner of a mill constructed a smoke-stack upon approved plans such as were in successful use elsewhere among others engaged in the same business. He operated this chimney during a period of seventeen years and established the fact that during that time no known spark had fallen from the chimney until the one charged to have caused damage to the plaintiff's property fell from it. An expert was called who expressed the opinion that the stack was surrounded by highly inflammable material and that it should have been higher and should have been equipped with a spark arrester. The court held that the owner was not liable unless he was shown to have failed to perform his common law duty thereto.

A North Carolina case has been decided in which it was held that the burden of proving that ordinary care and caution had been exercised in the erection, maintenance and operation of a chimney was upon the owner and not upon the party damaged by sparks falling from it.

In a Kentucky case it was held that the question of negligence is one for the jury to determine from the evidence. It was shown that the wind was blowing directly from the chimney upon the plaintiff's property, that the spark arrester was not in place upon the chimney and that the owner thereof was burning highly inflammable wood. Said the court: "There is no doubt about the liability of a person for the consequence of a fire negligently started or controlled, and the question of negligence in this case is properly submitted to the jury."

In a Michigan case it was held that the owner of a smoke-stack might be found guilty of negligence rendering him liable for a fire caused by sparks where he had failed to install a spark arrester upon his chimney, even though it was shown that such appliances were not commonly in use in the community. A Virginia case, however, held that the mere fact that a spark arrester had not been used upon a smoke-stack did not, in itself, establish that the owner thereof was guility of negligence, where he had used due care and caution in other respects, and where it was shown that the use of such spark arresters was not customary among others in the same business in his community. In a South Carolina case it was held that the mere failure to use a spark arrester upon a smoke-stack was not, as a point of law, sufficient to charge the owner with negligence in operation.

In a Michigan case it was held that the owner of a saw-mill may be guilty of negligence for a failure to shut down his mill during a high wind and to keep it shut down during such high wind, in order to prevent damage and loss to others in the vicinity. This is an extraordinary feature of the owner's liability worthy of more than passing interest. A similar ruling was made in a North Carolina case, but it was further held that if such a showering of sparks takes place during a high wind, it must be remedied at once if the owner is to escape subsequent liability, and that if the defect is not remediable the mill must not be operated at all.

It has long been a rule of law that whoever maintains or uses an agency highly dangerous to the community must take adequate measures to control such agency before he even begins to use it. Fire is a highly dangerous agency, if steps are not taken to control it. When under control, it is not dangerous, but highly useful. Its usefulness ceases the instant it gets beyond control. Hence the reason for the utmost care and caution in the use of chimneys, especially in localities where they are likely to cause damage and loss by fire. The only measure of safety is for the owner to use every care and caution known to prudent men in the same business, or known to science or skilled experts. Defective chimneys are a constant menace, and the man who maintains such a chimney is living in constant danger of a verdict for damages in favor of another if fires are caused.

Italy the Worst Sufferer from Fuel Shortage

Italy, whose population as a whole was without coal for heating and in large part without gas for cooking, for many months of the war period, was the worst sufferer from fuel shortage among the allied nations, according to the report of the commission sent to Europe by United States Fuel Administrator H. A. Garfield.

Switzerland, which now faces a severe shortage, managed throughout the conflict to obtain a considerable supply of coal from Germany, although under an agreement forced on her "upon disadvantageous terms," the report says. France is continuing to furnish to Switzerland the tonnage Germany had allotted from Alsatian fields. Germany was Switzerland's chief source of supply before the war.

Belgium, the commission found, should be able to produce immediately more coal than needed for its own consumption since its industries were so thoroughly ruined during German occupation.

Representatives of the Italian government, the commission reports, urge an annual national supply of 12,000,000 tons to meet actual requirements. The whole of this quantity would of necessity be imported since Italy's only domestic fuel is a very poor grade of lignite. Under the spur of war needs, however, the production of this lignite was forced up to 2,500,000 tons in 1918, as against 700,000 tons before the war.

Italy was receiving but 7,000,000 tons of coal during the last years of the war, the report says, as against minimum necessities of 10,000,000. The report expresses some doubt as to whether Great Britain will be able, "in view of conditions at home and the heavy demand at home and elsewhere," to resume the annual exports of some 8,500,000 tons to Italy maintained in pre-war years.

Discussing exports from the United States to Italy, the report says that "due in part to war conditions and in part to a coal strike in Great Britain, they rose from 82,000 tons in 1913 to 287,000 in 1914, to 1,714,000 in 1915 and to 1,040,000 tons in 1916." These figures, the report states, are from Italian governmental sources, and are smaller than those of United States records.

Professor Rolla C. Carpenter

Rolla C. Carpenter, who until less than two years ago was professor of experimental engineering at Sibley College, Cornell University, died at his home in Ithaca, N. Y., on Jan. 19. Professor Carpenter was born in Orion, Mich., in 1852, received his early education in the schools and colleges of that state and graduated from the University of Michigan in 1875 as a civil engineer. After graduation he spent one year in railroad construction. Later, he became professor of mathematics and engineering in the Michigan Agricultural College, which position he held until 1890, when he went to Cornell to take the professorship in experimental engineering. He received the degree of C. E. from his alma mater; of M.S. in 1876; LL.D. in 1907 from the Michigan Agricultural College, and M.M.E. from Cornell in 1888.

PROF. ROLLA C. CARPENTER

While at the Michigan Agricultural College at Lansing, Professor Carpenter was consulting engineer for the Lansing Engine and Iron Works, at which time he designed the governor for their automatic engine and also made a number of important tests to determine the friction of the various engines under different conditions. His consulting practice in other directions was also very large, as he was engineer for a number of important constructions and installations in the State of Michigan. Largely as a result of his work at Sibley College, Cornell has today one of the best organized and equipped experimental laboratories in the country, and in experimental work he has long been a recognized authority. In addition to his college work he continued to increase his extensive consulting practice in mechanical, electrical, heating and hydraulic engineering. He directed the installation of the high-pressure fire system of Baltimore in 1911 and installed a high-pressure pumping system in New York in 1912.

He was also a noted inventor and author. His inventions include among others a steam separator, a steam calorimeter and a fuel calorimeter. His books include the well-known textbooks, "Experimental Engineering," "Heating and Ventilating Buildings," and "Internal Combustion Engines." Besides these he has written many important articles for the American Society of Mechanical Engineers and for various engineering periodicals. He retired from Sibley College early in 1917 after nearly thirty years of teaching. He was a judge in the Department of Machinery at the Chicago Exposition in 1893, the Buffalo Exposition in 1901 and the Jamestown Exposition in 1907.

Professor Carpenter was a member of the following engineering societies and clubs: American Society of Mechanical Engineers, of which he was a past vice president; American Society of Heating and Ventilating Engineers, of which he was a past president; American Institute of Mining Engineers; American Society of Refrigerating Engineers; American Society for Testing Materials; American Society of Automotive Engineers; Michigan Engineering Society; the Engineers' Club and the New York Railroad Club.

The late Doctor Thurston said of Professor Carpenter's work as a teacher: "He has met with marked success, and his method of going directly to the pith of his subject has made him a famous lecturer with his students." He is survived by his widow and three children.

Pasadena's Light Plant Pays

The users of electric light in Pasadena, Calif., says the Kansas City *Star*, have saved on the average of $134,000 a year for the last eleven years by owning their own electric-light plant. The saving is calculated on the basis of the rates charged by privately owned plants in neighboring cities.

The report for the year, just issued, contains interesting information. Costs, of course, have been mounting steadily. The plant, for instance, uses oil fuel, and its cost has gone up 55 per cent. over the price of the year preceding. While the gross revenues are up 3 per cent., the net receipts are 14 per cent. below those of the previous year. Yet with allowance made for depreciation, for interest, and for taxes, the net earnings would be 6½ per cent. This showing was made with an average rate to consumers of a little less than 5 cents a kilowatt hour.

Pasadena, like Kansas City, Kan., finds the ownership and operation of an electric-light plant a highly profitable undertaking—although every privately owned corporation in the country can demonstrate that municipal ownership can never, never pay.

Permits Required for Certain Smokeless Coal Shipments

To correct a slight misconception of its order of Jan. 16, regarding the removal of restrictions on shipments of bituminous coal and smokeless coal by way of the docks on Lake Michigan and Lake Superior, the United States Fuel Administration points that this order still keeps in effect a provision that:

> Low-volatile smokeless coal shall not be sold or shipped from docks on Lake Michigan and Lake Superior for use by domestic consumers unless a permit for such sale or shipment shall first have been obtained from the district representative of the United States Fuel Administration in charge of said docks.

The order also declared valid all permits heretofore or hereafter obtained from the district representative in charge of said docks, under the proviso of the order of Jan. 2, 1919, although granted without the approval of the Federal Fuel Administrator.

The Keynote of Successful Management

Charles Schwab says that he has put into practice for thirty-five or forty years of industrial pursuits, one particular thing, which he believes is the keynote of everything he strives to do. That particular thing is encouragement and not criticism in dealing with all his men.

> I have yet to see the man, however great and exalted his situation, who is not susceptible to the approval of his fellow-men. I have yet failed to see the man who is worth calling a man, who does not put forth his best efforts under the approval of his fellow-men. And the severest criticism that can come to any man is not to be noticed at all. When a man is not noticed, he knows that he has not gained the approval of his fellows, but when he is approved he gives his best effort.

In nearly all cases the question of time enters in when renewing boiler tubes in order to get the unit in service as soon as possible. It is necessary in consequence to make careful plans to determine how the tube is to be removed from the boiler after being cut out and how it is to be replaced. The plan followed depends on local conditions, as the type of stoker and the position of boiler in the boiler room bring about varying situations. In each case the job should be sized up from every angle, and material and men provided so that no unnecessary delay will occur in the preliminary work or in the actual work of renewal. This includes getting together blocks and tackle, ladders, the instruction of the men, the removal of obstructing brick, opening of coal-bunker doors, etc. The new tubes should be assembled and cleaned, and the ends first to go into the firebox noted, as well as the number of the tube, which indicates the row in which it is to be placed.

New Publications

HYDRAULIC EXPERIMENTS WITH VALVES, ORIFICES, HOSE, NOZZLES AND ORIFICE BUCKETS. By Arthur N. Talbot, Fred B. Seeley, Virgil R. Fleming and Melvin L. Enger. Published by the University of Illinois, Urbana, Ill. Paper, 6 x 9 in.; 76 pages; 28 illustrations. Price, 35 cents.

This bulletin, which is No. 105 of the series published by the Engineering Experiment Station of the University of Illinois, contains the results of four separate sets of experiments that were made in the investigation of certain problems and that were not judged extensive enough to warrant publication as separate bulletins. The investigations are largely the outgrowth of experimental work begun by students in the preparation of theses and extend over a number of years. The experiments are not exhaustive in their scope but it is believed that the data obtained are of sufficient value to warrant publication. The four papers in the bulletin are entitled: "Loss of Hydraulic Head in Small Valves"; "Flow of Water Through Submerged Orifices"; "Fire Streams from Small Hose and Nozzles"; and "The Orifice Bucket for Measuring Water."

Personals

William McElraevy has been appointed district manager of the Dominion Asbestos and Rubber Corp. of New York. Mr. McElraevy was formerly manager of the New York branch of the power plant specialty department of the H. W. Johns-Manville Co., in which capacity he served for nine years.

Engineering Affairs

The American Society of Heating and Ventilating Engineers will hold its annual meeting at the Engineering Societies Building, 29 West 39th St., New York, Jan. 28-30. The program promises to be an interesting one and a very successful meeting is anticipated.

The Ohio Engineering Society on the first day of its annual convention in Columbus, voted unanimously in favor of the principle of licensing engineers. It is expected that a bill will be presented to the state legislature at its present session. The action of the Ohio Engineering Society followed an address on "Licensing," by C. E. Drayer, secretary of the American Association of Engineers.

The American Association of Engineers—The Compensation Committee of the Chicago Chapter, will report at the regular meeting Friday, Feb. 7. A paper will be presented by J. H. Prior formerly chief engineer, Illinois State Public Utilities Commission, followed by a discussion prepared by Langdon Pearse, engineer, Sanitary District of Chicago. The committee is considering tables of minimum salaries for engineers, which have been placed before the Chapter.

Miscellaneous News

A Boiler Exploded in the steam-heating plant of the Denver (Colo.) Gas and Electric Light Co. on Jan. 14, killing one of the firemen and injuring two others. All the piping in the rear of the boiler was blown out. The cause of the explosion is unknown.

Zone Regulations on Coke and all coal except Pennsylvania anthracite will be suspended Feb. 1, it has been announced by the Fuel Administration. Likewise all price regulations, including agents' commissions and wholesale and retail margins on coke and all coal, except Pennsylvania anthracite, will be suspended. These regulations, it was announced, are subject to reinstatement, if price, wage, labor, production or other conditions arise that require it.

Business Items

C. S. Hallowell, Inc., has opened offices at 103 Park Ave., New York City, for the conduct of a general advertising agency.

Busch-Sulzer Bros.-Diesel Engine Co., who have been engaged in building marine engines for government work during the war, announce that they have again resumed commercial business.

Plant Analysis Service of the Goodyear Rubber Co.—Plant analysis in reference to the belt drives of a given plant is a comparatively new department of the Goodyear Tire and Rubber Co. Its function is to examine a plant and make recommendations as to the proper belting, strength, size and other conditions to cover the particular needs involved. The service of the staff of experts is available on application to the company.

The Wheeler Condenser and Engineering Co., of Carteret, N. J., has obtained from the Schütte & Koerting Co., of Philadelphia, through the Alien Property Custodian the exclusive right to manufacture and sell steam-jet air pumps under patent No. 968,926 in connection with surface condensers, jet condensers, barometric condensers, vacuum pans and evaporating apparatus. This patent covers the feature of two or more steam jets working in series with a condenser between the jets.

Trade Catalogs

The Prevention of Rusting or Corrosion of Iron and Steel. Dearborn Chemical Co., Chicago, Ill. An attractive 24-page booklet fully describing the company's list of specialties which are at present being put on the market. A copy may be had upon application to the company's Department of Specialties.

The Jeffrey Manufacturing Co., of Columbus, Ohio, has just issued its catalog No. 244, which contains 40 pages, illustrated and devoted to details of elevators selected out of numerous styles used in the handling of a wide range of materials in various industries throughout the country. The numerous examples and subjects outlined in this book enable the prospective purchaser to readily select the proper standard elevator to meet his requirements, thus saving time and expense required in making layouts and drawings for his own particular needs.

New Construction

PROPOSED WORK

Mass., Danvers—The town has petitioned the Legislature for authority to borrow $20,000 to rebuild and relay its water-mains and improve the storage pumping and distribution facilities.

Conn., Danbury—The Connecticut Power & Lighting Co. plans to build additions to its plant.

N. Y., Brooklyn—The Brooklyn Synagague, 1093 Sterling Pl., will install a steam heating system in its proposed 2 story, 80 x 100 ft. synagague. Total estimated cost, $100,000. M. Raisin, Rabbi.

N. Y., Brooklyn—R. T. Short, Arch., 370 Macon St., will receive bids until Feb. 1, for the erection of a 2 story, 80 x 180 ft. theater on Flatbush and Rogers Ave., for the Jewel Building Co.,170 Broadway, New York City. A steam heating system will be installed in same. Total estimated cost, $250,000.

N. Y., New York—Gronenberg & Leuchtag, Arch., 303 5th Ave., will receive bids until Apr. 2, for the erection of a 10 story, 100 x 100 ft. hotel on 43rd St. near 8th Ave. for Henry Claman, 243 West 43rd St. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. Y., New York—A. C. Merkle, Inc., 233 Broadway, will install a steam heating system in the 4 story factory, which will be built on West and Horatio St. Total estimated cost, $145,000. A. L. Lucius, 38 Park Row, Arch.

N. Y., Sonyea—P. L. Lang, Pres. Bd. of Mgrs., Graig Colony for Epileptics, 7 Wall St., New York City, received bids for installing a heating system in the new kitchen building, from E. Towe, 32 Oak St., Rochester, $7200; Austin Heating Co., 121 West 42nd St., New York City, $8875; Murtaugh & Reddington, 26 Pleasant St., Rochester, $8987.

N. Y., S. I., Stapleton—J. A. Wetmore, Superv. Arch., Treas. Dept., Washington, D. C., will receive bids until Feb. 10, for the installation of a heating boiler, hot water tank, etc., for the hospital unit, type A, at the U. S. Marine Hospital here.

N. Y., Utica—The State Hospital Commission, Capitol, Albany, will receive bids until Feb. 11, for the installation of boilers, piping, etc., at the Utica State Hospital, here. Estimated cost, $75,000. Noted Jan. 14.

N. Y., Watertown—City has had plans prepared by T. L. Tomlines, Eng., City Bank Bldg., Syracuse, for the development of power at the Diamond Island site on the Black River. Plans will include the erection of concrete dam, power house and tail race. Total estimated cost, $600,000 of which about $170,000 has already been appropriated.

N. J., Linden—The Board of Education received only bid for installing a heating system in the proposed addition to P. S. No. 2, from J. H. Cooney & Co., 210 North 4th St., Harrison, $6500.

N. J., Newark—E. and H. Levy plan to build a power house on Purdy St.

Penn., Springdale—The Penn Power Co., Benedum Trees Bldg., Pittsburgh, is building 1 story, 200 x 900 ft. power plant in connection with a mine development here. Total estimated cost, $5,000,000. Sanderson & Porter, 52 William St., New York City, Engr.

Md., Princess Anne—Town plans to build a water distribution system. Plans include the erection of 1 or more wood stave tanks, installation of a gasoline pump, etc. Estimated cost, $60,000. C. Lanksford, Pres. L. J. Houston, Fredericksburg, Engr.

Ga., Cordele—City plans to build an electric lighting plant Address the Mayor.

Miss., Iverness—City will receive bids in March for improvements to its electric lighting plant and water-works system. Plans include installing oil engines, pumps, alternators, miscellaneous line material, etc. Former bids were rejected. X. A. Kramer, Magnolia, Engr. Noted Dec. 31.

Tenn., Morristown—The Southern Ry., 1300 Pennsylvania Ave., Washington, D. C., plans to build a pumping station near here. W. H. Wells, Washington, D. C. Ch. Eng.

Ohio, Cleveland—W. R. Powell, Arch., 705 Rose Bldg., will receive bids until Mar. 15, for the erection of a 2 and 6 story, 78 x 381 ft. market house at 11826 Detroit Ave., for the Lakewood Market House Co. A steam heating system and refrigeration plant will be installed in same. Total estimated cost, $200,000.

Ohio, Norwood—The Board of Education will receive bids until Feb. 24, for the erection of a [illegible] story, 80 x 139 ft. school on Allison St. A hot air heating system may be installed. Total estimated cost, $150,000. H. Hake, Telephone Bldg., Cincinnati, Arch.

Ohio, Oberlin—The Board of Education will install a steam heating and ventilating system in the proposed 2 story, 75 x 180 ft. high school which it plans to build. Total estimated cost, $225,000. E. F. A. Root, Pres. F. C. Warner, 767 Hippodrome Bldg., Cleveland, Arch.

Ind., Rockport—Commissioners of Spencer Co. will receive bids until Mar. 3, for the erection of a 2 story, 105 x 112 ft. courthouse. A vacuum and C. I. radiation system and low pressure boilers will be installed in same. Total estimated cost, $175,000. Snider & Rotz, 703 Merchants Bank Bldg., Indianapolis, Heating Eng.

Mich., Bay City—City plans to build an addition to its electric light and power plant. New equipment will also be installed. Estimated cost, $125,000. C. L. De Bates, Supt.

Mich., Detroit—The Morgan & Wright Tire Co., foot Bellevue St., will install a steam heating system in the proposed 7 story, 140 x 215 ft. warehouse which it plans to build. Total estimated cost, $750,000. Lockwood Greene & Co., 38 South Dearborn St., Chicago, Ill., Eng.

Mich., Kinds—Village voted to issue $10,000 bonds to purchase and install electric lighting equipment.

Ill., Lewistown—The Thompson Drainage & Levee Dist., Fulton Co., will receive bids until Feb. 3, for the erection of a pump station equipped with 3 low lift, double suction centrifugal pumps with intake and discharge pipes, 3 electric motors, 1 motor exhauster, switchboards, meters, electric lighting, etc., in connection with the irrigation project here. Goodell & Millard, Beardstown, Eng.

Wis., Sheboygan—The Badger State Tanning Co., South Water St., will receive bids in February for the erection of a 2 story, 68 x 114 ft. addition to its power house. Juul & Smith, Imig Bldg., Arch.

Kan., Hiawatha—City is having plans prepared by Black & Veatch, Eng., Interstate Bldg., Kansas City, Mo., for the construction of a water supply pump house, transmission line, etc.

Neb., Lincoln—City is having plans prepared by A. Dobson, City Eng., for the erection of an addition to the power house. New equipment will be installed in same.

Mont., Cascade—City will receive bids until Feb. 3 for the erection of a 14 x 14 ft. pump house and will install a 10 hp. motor direct connected to a triplex pump 100 gal. per minute.

Ark., Benton—G. A. Smith, Supt. of Water Plant, has acquired an electric plant and will install an engine and a 125 kw. generator in same.

Okla., Duncan—City will award the contract for the erection and equipment of an electric lighting plant and a water-works system. Benham Eng. Co., Colcord Bldg., Oklahoma, Consultg. Engr.

Colo., Holyoke—The town will soon award the contract for the construction of a pumping plant and the installation of two 125 k.v.a. alternators, one 10,000 gal. fuel oil tank, etc. R. D. Salisbury, 1415 East Colfax Ave., Denver, Eng.

N. M., Mountainair—R. Adams and C. H. Eichelberger have applied for a franchise to build and operate electric-light and water works systems here.

Utah, Castlegate—The Utah Fuel Co. is having plans prepared for the erection of a water purification plant. Project includes a rapid sand filter, storage tanks, pumping plant, etc. Estimated cost, $40,000.

Wash., Valley—The Admiral Mining Co. is building a water power plant to have a capacity of 130 h.p., a compressor plant with 8 drill capacity and a concentration mill with 250 ton daily capacity. Extensive additional underground development is also contemplated. About $75,000 will be expended on project. J. R. Brown, 402 Rookery Bldg., Spokane, Mgr.

Calif., El Centro—The Southern Sierra Power Co., Riverside, plans to build a 30 mi. high tension transmission line from here to Calexico. Estimated cost, $35,000. A. B. West, Riverside, Gen. Mgr.

Calif., Los Angeles—The Southern California Edison Co., 301 South Broadway, plans to expend about $20,000,000 to develop 150,000 additional horsepower in the hydro-electrical plants and building transmission and distributing lines throughout southern California. W. Dennis, Ch. Engr.

Ont., Amherstburg—Brunner Mond Co. of Canada, Ltd., plans to build a transmission system along certain highways in Anderdon Township. A. C. Maillon, Clk.

Ont., Ancaster—City will vote on a by-law for the installation and supply of hydro-electric power. Estimated cost, $17,000.

Ont., Toronto—City plans to extend its hydro electric line. About $650,000 will be expended.

Que., Sherbrooke—City will issue $90,000 debentures for the construction of electric distributing stations.

CONTRACTS AWARDED

N. Y., New York—M. Groh's Sons, 238 West 28th St., has awarded the contract for the erection of a 10-story, cold-storage warehouse, to Potterson Bros., 215 West 28th St. Estimated cost, $250,000. Noted Dec. 31.

N. Y., Niagara Falls—The Niagara Falls Power Co., Canal Basin, has awarded the contract for the erection of a 3-story, 99 x 158 ft., power substation, to the Snyder-Gillette Contg. Co., Gillette Court. Estimated cost, $35,000.

N. Y., Rockaway—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids Jan. 20 for installing a heating system in hangars C, D and E. (work complete), from the Austin Heating Corporation, 121 West 42nd St., New York City, $25,745; American Foundry & Furnace Co., 1008 Mutual Bldg., Richmond, Va., $25,815 (90 days); Gillis & Gehagen, 537 West Broadway, New York City, $25,936 (60 days). Noted Jan. 14.

N. J., Jersey City—The Ewald Box Manufacturing Co. has awarded the contract for changing its factory from a steam into an electric plant, to W. Coleman, 11 Willow Court. Estimated cost, $3000.

Penn., Philadelphia—City received only bid for the erection of a power plant, fire and police station at 24th and Rittner Sts., from F. H. Stewart Electric Co., 37 North 7th St., $304,245. Noted Dec. 31.

Penn., Pittsburgh—The Carbon Steel Co., 32nd St. and Allegheny River, has awarded the contract for the erection of a 1-story, 40 x 168 ft. boiler house, to W. N. Kratzer & Co., 3212 Smallman St.

Va., Norfolk—The Norfolk & Hampton Road Dry Dock & Ship Repairing Co., Bank of Commerce Bldg., has awarded the contract for the erection of a shipbuilding plant consisting of various 1-story buildings, to J. Stewart & Co., 30 Church St., New York City. A steam heating system will be installed in same. Total estimated cost, $7,000,000.

Ohio, Columbus—The U. S. Government, Washington, D. C., has awarded the contract for the erection of 145 one story additions to the storehouse here, to the Hunkin-Conkey Co., 601 Century Bldg., Cleveland. A steam heating system will be installed in same. Total estimated cost, $1,500,000.

Iowa, Sioux City—The Mariner Terminal Elevator Co., Grain Exchange, has awarded the contract for the erection of a terminal elevator on 5th and Pavonia St., to the Younglove Constr. Co., 412 United Bank Bldg. Estimated cost, $150,000. Eighteen 500 h.p. electric motors, dryer, boiler and radiation system will be installed in same.

Kan., Garnett—City has awarded the contract for the erection of a pump house and pit on Cedar Creek near here, to A. H. Stimson, Topeka. Estimated cost, $5110.

N. S., Sydney—The Dominion Iron & Steel Co. has awarded the contract for the erection of a power station capable of developing 11,500 kw. to the Foundation Co., Ltd., 224 St. James St., Montreal, Que.; cost plus percentage.

Ore., Portland—The Dock Commissioners received bids Dec. 30, for the installation of electric appliances at Pier No. 1 of St John's Terminal, from the National Electric Co., Railway Exchange Bldg., $17,422; Jaggar Sroufe Co., 103 West Park, $20,190; NePage-McKenny Co., 388 Burnside St., $20,612.

THE COAL MARKET

BOSTON—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$.05
Rice	2.90	Barley	2.40

All rail to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90

NEW YORK—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

PHILADELPHIA—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

CHICAGO—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.30	2.75—2.90

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

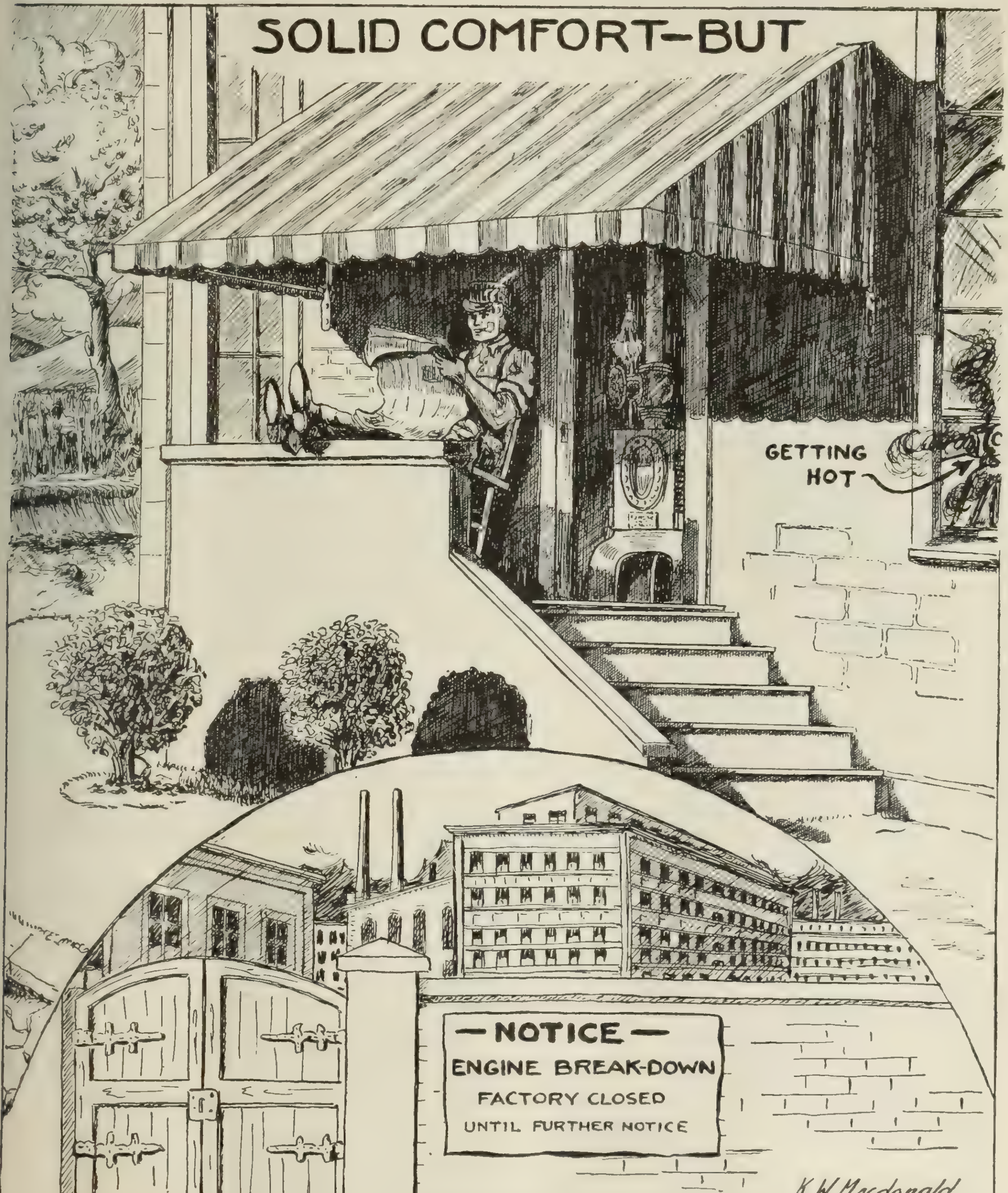
ST. LOUIS—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

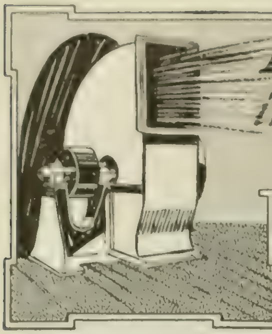
Williamson-Franklin rate to St. Louis is $1.10, other rates p. 95.

POWER

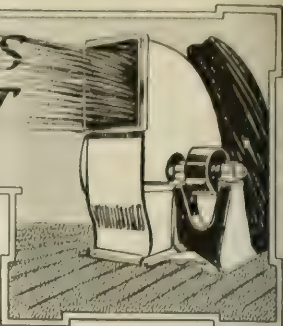
Volume 49 New York, February 4, 1919 *Number* 5



SOLID COMFORT—BUT



FANS and BLOWERS in the POWER PLANT



By Rufus T. Strohm

Descriptive article covering the principles of action and the features of construction of the different types of fans and blowers with which the power-plant engineer may have to deal.

SUCH requirements as the production of forced or induced draft, the ventilation of rooms or buildings, the removal of gases or light refuse from workshops or factories, and the furnishing of quantities of air for drying or heating in manufacturing processes necessitate the use of fans and blowers, and the equipment for rendering these forms of service is ordinarily in charge of the engineer of the power plant.

The type and design of the fan or blower will depend on the duty it must perform. For example, it may have to supply a small volume of air at high pressure or a large volume of air at low pressure; it may have to force the air through pipes or ducts, as in ventilating systems; or it may discharge the air freely into the atmosphere, as in the case of exhausting foul air from a mine.

Fans may be divided broadly into two classes; namely, centrifugal fans and disk fans. A centrifugal fan is one that causes the air to move by subjecting it to the action of centrifugal force. The type of fan shown in Fig. 1 acts on this principle. It consists of a number of flat blades *A* arranged radially around a driving shaft *B* and held to it by arms *C*, the whole being inclosed in a casing *D* that is open at the center, forming the inlet *E*, and that has a discharge opening at *F*.

The shaft *B* is rotated by a belt and pulley or by a direct-connected engine or motor. As the blades *A* sweep around inside the casing they carry the air around with them, and as the air has weight, the rotary motion sets up centrifugal force that throws the air outward. The movement of the air away from the shaft causes a partial vacuum at the center of the fan wheel and a corresponding increase of pressure at the tips of the blades. As a consequence, the air that is thrown outward against the casing escapes by way of the discharge outlet *F* while at the same time air enters through the central opening *E* to fill the partial vacuum formed around the shaft. There is thus set up a continuous flow of air inward at the center and outward at the discharge opening.

A disk fan is shown in Fig. 2. It consists of a number of radial blades *A* fastened to a central driving shaft *B* but set at an angle to the shaft, as in the familiar windmill. A narrow casing *C* surrounds the fan. When the shaft *B* is rotated, air is drawn into the fan at one side and discharged at the other, in a direction parallel to the shaft. In this respect it differs from the centrifugal fan, which discharges the air at right angles to the shaft.

The disk fan, while simple in construction, is not adapted to work against much resistance. It simply propels the air and is unable to build up any considerable pressure on the discharge side. The reason is that there is so much opportunity for leakage of air back through the revolving blades, particularly at the center of the wheel, where the linear velocity of the blades is small. Both the inlet and the discharge should be free and unconfined. Accordingly, the disk fan is used in the ventilation of offices, workrooms, engine and boiler rooms, kitchens, restaurants and the like. The fan is commonly set so as to fit closely an opening

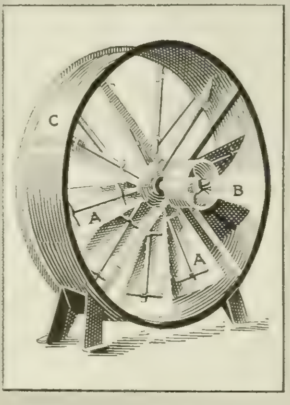


FIG. 2. DISK TYPE OF FAN

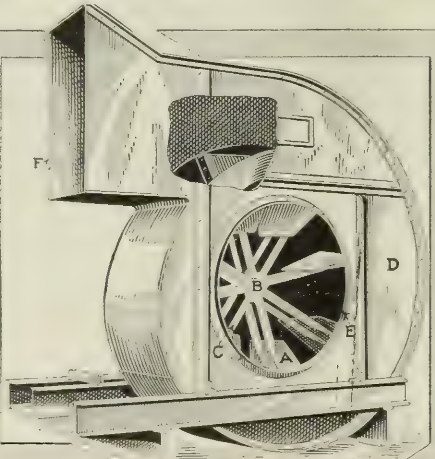


FIG. 1. CENTRIFUGAL TYPE OF FAN

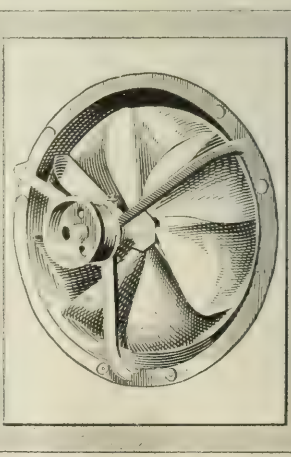


FIG. 3. PROPELLER TYPE OF FAN

in the wall and discharges the steam, smoke or heated air directly into the outer atmosphere.

If the pressure on the outlet side of a disk fan is increased—as by discharging the air through a long pipe that offers considerable resistance to flow—the air slips back through the slow-moving center of the fan and power is used without producing any useful effect. It can be imagined that the pressure on the discharge side could be increased to such an extent that the leakage backward would equal the discharge forward and the fan would simply churn the air without producing any flow at the end of the discharge pipe.

A modification of the disk type of fan is the propeller fan shown in Fig. 3. The blades are scoop-shaped, the purpose being to handle the air without setting up reverse currents. The efficiency of the fan is thereby increased. The width and curvature of the blades at their outer ends, where their velocity is greatest, are such as to pick up the air without shock and at low pressure and move it forward, discharging it at high velocity parallel to the shaft. The propeller fan is used for the same classes of service as the disk fan.

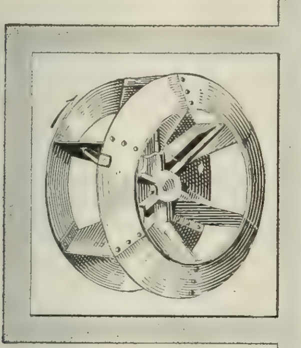


FIG. 5. FAN WHEEL WITH STRAIGHT BLADES

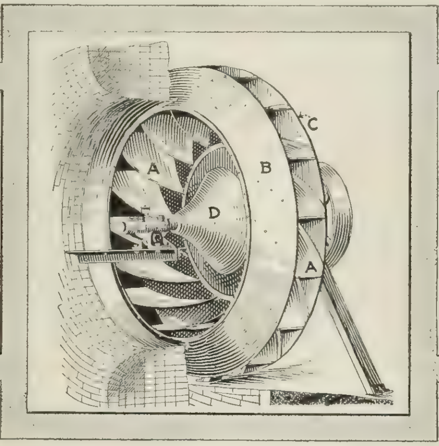


FIG. 4. CONE TYPE OF FAN

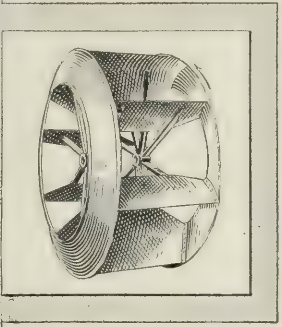


FIG. 6. FAN WHEEL WITH CURVED BLADES

Because of the friction of the air against the surfaces of the blades, there is a tendency for a disk fan to throw some of the air outward radially, as in the centrifugal type of fan. The desire to utilize this centrifugal effect to good advantage led to the manufacture of the cone type of fan, an example of which is shown in Fig. 4. The blades *A* are curved and are riveted to the two side plates *B* and *C*. The plate *B* is cut away at the center so as to form the inlet opening of the fan wheel. The plate *C* is solid and against it is fitted the base of the conical deflector *D* that surrounds the shaft. The edges of the blades *A* are tapered down from the edge of the inlet opening to the base of the deflector.

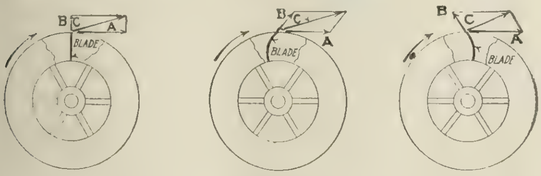


FIG. 7. EFFECT OF BLADE CURVATURE ON VELOCITY OF DISCHARGE

When the wheel is rotated, the air between the blades is thrown outward by centrifugal force and is discharged into a duct or casing surrounding the wheel circumference. The air that rushes in through the inlet opening, parallel to the shaft, strikes the cone *D* and is deflected outward, where it is caught by the blades and forced out to the discharge. The change of direction of the air is thus made smoothly, and there is little loss due to friction and reverse currents. The cone fan is used to move air under small pressure and is run at moderate speeds; that is, the outer edges of the blades are run at about 5000 ft. per minute.

The standard steel-plate fan is a centrifugal fan with straight blades, comparatively few in number, as indicated by the fan wheel shown in Fig. 5. In this case a single set of arms cast into the hub is used, but for wide wheels it is necessary to provide two sets. The blades are riveted to the side plates to obtain a strong construction. It will be observed that the side plates are not parallel, but converge toward the outer edge, thus decreasing the size of the air space between adjacent blades. The reason is that the velocity of the air increases as it moves away from the shaft and consequently the passage of a given volume can be accommodated by a smaller area of cross-section.

Steel-plate fans may be made with curved blades and the curvature may be either forward, in the direction of rotation, or backward in the opposite direction. The fan wheel of a steel-plate fan with curved blades is shown in Fig. 6. There are two hubs and sets of arms and the blades are curved backward at their outer ends.

The effect of the curvature of the blades may be illustrated by the diagrams in Fig. 7. In the first of these the blade is straight and radial, in the second it is curved forward and in the third it is curved backward. In all three sketches the linear velocity of the tips of the blades is the same, as represented by the length of the line *A*. Similarly, the line *B* represents the radial velocity of the air at the moment it leaves the blade. By completing the parallelogram of velocities and drawing the diagonal, the line *C* represents the direction and velocity of the discharged air. In the case of straight blades and blades curved forward the resultant velocity of the air is greater than that of the blade tips, but in the case of blades curved backward it is less than the speed of the blade tips.

The next step in fan development was the production of the sirocco or multiblade type, one form of which is illustrated by the fan wheel in Fig. 8. The number of blades is very much greater than in the steel-plate fan, the depth of the blades is much less and the area of inlet opening is greatly increased. The blades are curved forward in the direction of rotation. The advantages gained by this construction are many. The inlet opening is made almost equal to the diameter of the wheel, because of the shallowness of the blades. The space between adjacent blades is small, and eddy currents are less likely to be set up. At the inner end the blade curve is approximately at right angles to the direction of motion, but at the outer end it is inclined forward at a sharp angle. As a result, the space between adjacent blades grows narrower toward the tips and the velocity of the air is increased as it flows outward. With a fan of this type the volume and velocity of air discharged at a given speed are considerably greater than for a steel-plate fan at the same speed. Noise and vibration are greatly reduced by the use of the multiblade construction. Another make of multiblade fan wheel, having but a single inlet, is shown in Fig. 9. In this case the overhung end of the wheel is braced and stiffened by four stay-rods riveted to the ring *A* and bolted into the hub *B*. The hub is made conical to deflect the incoming air outward into the blades with as little commotion as possible. This make of wheel is also built with double inlets, consisting practically of two single-inlet wheels placed back to back.

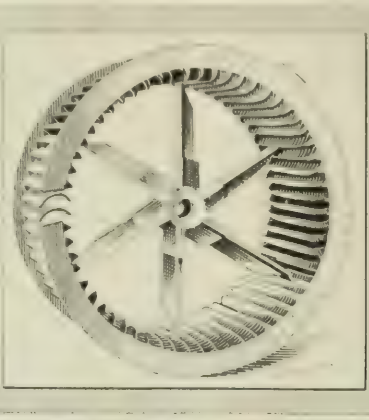


FIG. 8. MULTIBLADE TYPE OF FAN WHEEL

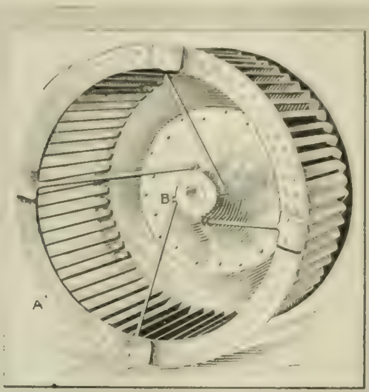


FIG. 9. SIROCCO TYPE OF FAN WHEEL

A further development of the multiblade construction is shown in Fig. 10. As in the types already illustrated, the blades are curved forward from the inner to the outer edges. In addition they are curved from side to side so as to produce a number of pockets in each blade. The object of this construction is to obtain a more uniform distribution of the air along the blade, eliminate side slip of the air along the blade due to its entrance velocity and direction and increase the velocity of discharge. The illustration shows a wheel for a fan of large size, the central annular ring serving to stiffen the wide wheel.

The conoidal fan wheel shown in Fig. 11 is simply the application of the cone principle to the multiblade type. The multiblade fan causes a rapid flow of air into the inlet opening, and there is a tendency for the rear ends of the blades to take most of the air. The conoidal fan has blades that are narrow at the front and wide at the rear and the angle of curvature is sharper at the front than at the rear, so that the work may be distributed evenly over the blade. A conical hub deflects the air outward with small loss of power or efficiency. Blowers and exhausters are centrifugal fans of practically the same internal construction. The difference between them is that the blower has two air inlets, whereas the exhauster has but one. A blower of a widely used type is shown in Fig. 12, consisting of a cast-iron casing inside which rotates a wheel much like that shown in Fig. 5. This form of blower is particularly adapted to furnishing forced draft for boilers and blowing powdered coal into furnaces, although it is used for many other purposes.

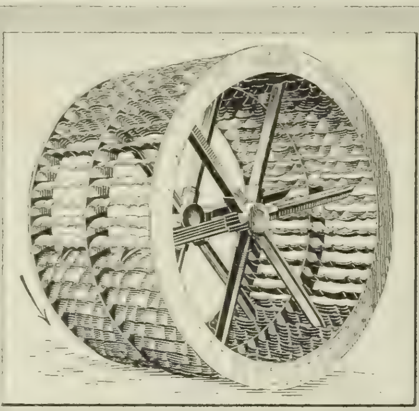


FIG. 10. LARGE WHEEL OF MULTIBLADE TYPE

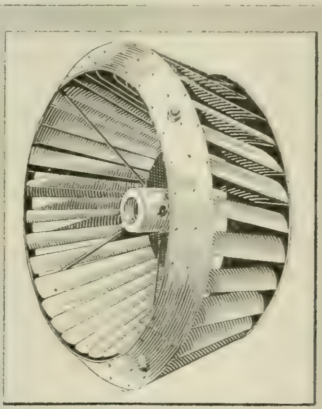


FIG. 11 FAN WHEEL OF CONOIDAL TYPE

For pressures as high as 16 oz. per square inch the style of blower shown in Fig. 13 is available. The casing is made in halves, one of which is removed to show the wheel. It is composed of a large number of narrow curved blades held between side plates and made with two inlets. The pressure of the air discharged depends on the speed of the wheel. It is designed to produce a high velocity of discharge and so deliver a small volume of air at high pressure. It will be noted that the blower in Fig. 13 bears a strong resemblance to a centrifugal pump. The principle of action is the same, in that the fluid is given a high velocity by the rapid rotation of the fan wheel or impeller and then the kinetic energy of the swiftly moving stream is converted into pressure by reducing the velocity. This change of velocity into pressure is accomplished by the spiral casing into which the air is discharged.

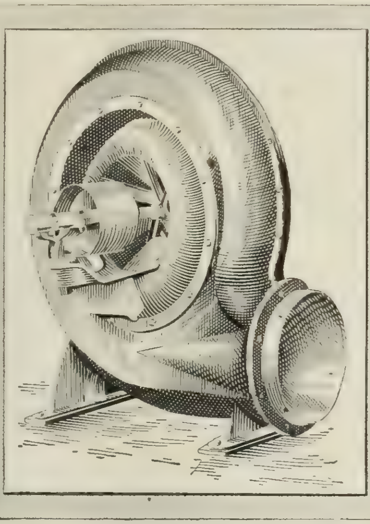


FIG. 12. EXTERIOR OF A COMMON TYPE OF BLOWER

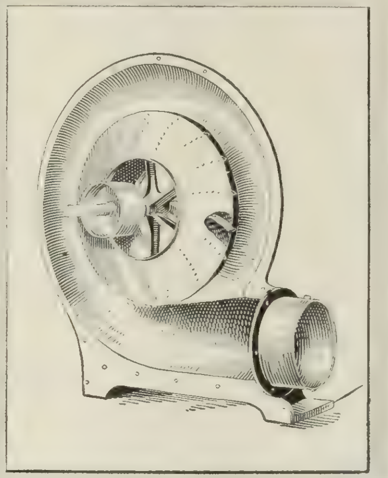


FIG. 13. SECTION OF HIGH-PRESSURE BLOWER

What is known ordinarily as a positive blower is shown in section in Fig. 14. It consists of a pair of two-lobed impellers *A* and *B* that run together inside a casing *C*. The shafts to which the impellers are keyed are forced to turn at the same speed by being connected by a pair of gears of the same size on the outside of the casing. Air enters at *D*, is caught between the impeller and the casing as at *E* and is carried around and discharged at *F*. As the impellers are in contact with each other and with the walls of the casing, there is no chance for the air to return and a definite volume is delivered at each revolution. This type of blower is used for furnishing air blast to forges and cupolas.

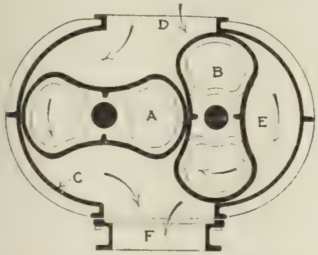


FIG. 14. DIAGRAM OF POSITIVE BLOWER

If the steel-plate casing incloses the entire spiral passage around the fan wheel, as in the fan shown in Fig. 1, it is called a full-housed fan. In many cases, however, a part of the passage is formed in the foundation on which the fan is placed, and the fan is then said to be three-quarters or seven-eighths housed, depending on how deeply it is set. In Fig. 15 the fan at the left is three-fourths housed and the other is seven-eighths housed.

The discharge of a fan is designated as top or bottom horizontal, top or bottom vertical, etc. For example, Fig. 1 shows a right-hand top horizontal discharge, while Fig. 15 shows at the left a left-hand top vertical discharge and at the right a left-hand top horizontal discharge. The hand of a fan is determined by standing so as to face the driving pulley and noting on which side of the shaft the fan outlet lies. The capacity of a fan—that is, the number of cubic feet of air per minute that it will discharge—depends on the speed of the fan and the pressure against which it works. Obviously, these conditions are different for different applications, and for that reason it is not feasible to show either a table or a formula that will give the capacity of a fan under any and all conditions of service.

Every fan manufacturer publishes tables of capacities of his different styles of fans at various speeds and pressures and these should be used when information as to capacity is desired. In some cases the tables may not allow for internal friction or resistance due to pipes and ducts. It is well, therefore, to determine first of all the basis on which the table is computed. If the resistances are not taken into account, the stated capacity will be larger than can be obtained in practice. Similar tables are published as to the horsepower required to drive fans. Here again it is best to rely on the data given by the manufacturer, as they include the results of wide experience in the use of fans.

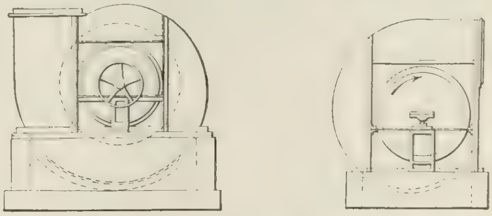


FIG. 15. THREE-QUARTERS AND SEVEN-EIGHTHS HOUSED FANS

Care of Heating and Ventilating Equipment—VII

BY HAROLD L. ALT

This article is a discussion of the two-pipe system of heating, giving pointers on the things to guard against to avoid trouble and how to correct certain defects when found to exist.

TWO-PIPE gravity steam systems utilize the same types of steam and air valves as one-pipe systems, and like the one-pipe system the piping may be arranged for up-feed (Fig. 1) or down-feed (Fig. 2) and either may have the air valve discharged into the room or connected to an air-line system either with or without an air-line pump as previously described. The down-feed, or "Mills system," allows the use of slightly smaller risers or, rather, drops, and since the condensation flows in the same direction as the steam, the danger of water-hammer and noise is greatly reduced. The two-pipe system is distinguished from the one-pipe by the radiators having a separate return connection which allows the condensation to flow down a different riser from that from which the steam is fed to the radiator, but the horizontal main piping, header or loop, may be almost identical with that used for a one-pipe system.

The standard tappings for two-pipe gravity steam radiators are as follows:

Radiator Surface	Supply Pipe	Return Pipe
Up to 48 sq ft	1 -in.	¾-in.
48 to 96 sq ft	1¼-in	1 -in
Over 96 sq ft	1½-in.	1¼-in

If the runout from the riser to the radiator is long, it is generally made one size larger up to the radiator valve. To operate in a quiet and satisfactory manner the horizontal piping must be large enough to supply the maximum amount of steam and must be properly pitched and dripped so that no water can accumulate in it, otherwise there will be objectionable noise. As a general thing but little trouble is encountered on account of the pipe not being big enough to deliver the required amount of steam, because the average demand is small and the maximum load in a heating system is carried only for a few days out of the entire heating season. While it is entirely feasible in heating work to run the drip in both the main header and riser against the flow of the steam, owing to the low velocities used, it is always better to arrange for the drip or condensation to flow with the steam instead of against it; therefore such piping is recommended as being theoretically correct and smaller pipes may be used, giving greater economy. As a rule the steam main rises from the boiler to a high point and then slopes downward from this point to the end of the line or point of drainage of the loop. This does not mean that there cannot be a further rise at any point where it may be desirable, but a drip must be provided, as illustrated in Fig. 3, at the point of rising.

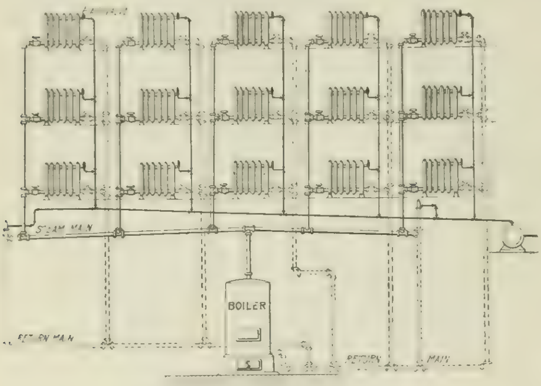


FIG. 1. TYPICAL TWO-PIPE UP-FEED SYSTEM

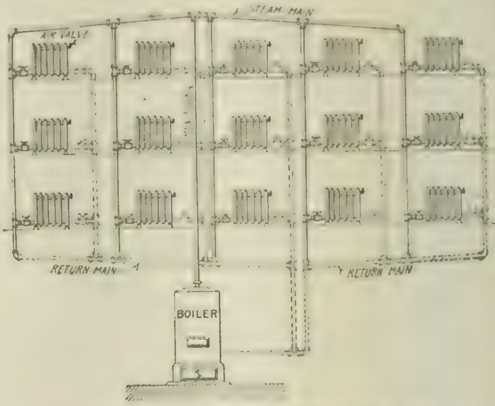


FIG. 2. DOWN-FEED TWO-PIPE JOB

"Wet" returns are always preferable, and if it is impossible to carry them below the boiler-water line, a false water line may generally be used. In many systems not operating properly, the trouble may be traced directly to the dry return or air binding or both.

Piping systems, on the supply steam side, may be divided into steam mains carrying all condensation or those carrying no condensation except their own and that for short distances while the return lines are either "wet" or "dry." Drips, bleeders or air lines do not materially affect these classifications.

The most common system of steam piping on small jobs—which at the same time utilize one-pipe radiators—is that known as the circuit or loop system. A typical layout of such piping is shown in Fig. 4, and it will be noticed that the main rises up directly from the top of the boiler to its high point, slopes steadily down from there until it completes its circuit, dropping below the water line near the boiler. If it is necessary to raise the main at any point, it may be done as shown in Fig. 3. With such a main there is practically no return pipe and one-pipe radiators are almost invariably used, the one-pipe risers being branched from the main as illustrated in detail at *A*, Fig. 5, using a tee turned to 45-deg. and a 45-deg. elbow. This results in the steam entering the branch without conflict with the condensation returning in the lower portion of the branch, but if the branch is taken from the main vertically, as at *B*, then the steam flowing in the main must force its way through a spray of water at each branch, interfering with the flow and causing more or less drop in pressure.

Probably the most frequent cause of trouble in such a piping system is the neglect to provide properly for air relief, for some steamfitters are not as familiar with the essential points on air relief as might reasonably be expected. Of course, air relief in the radiators is secured through the radiator air valve, but air may also be contained in steam piping, especially large mains, so that when the main cannot easily be relieved through the radiator connections, separate air venting must be installed. If no air valve is placed at the point where the main drops below the water line, the operating engineer is likely to experience trouble every time the system is started up, because air gets trapped in the main between the water and steam, thus interfering with the returns and circulation. Placing an air valve at such a point will relieve the air, but may result in trouble from water leakage due to the cooler water of the return spouting through the open valve. This can usually be remedied by locating the air valve 12 to 18 in. above the header, as shown in Fig. 6, so that the air and water will separate before reaching the air valve; but if the steam main is too small, the water may back up into the valve from the boiler, especially when the level of the low point of the steam main is near the water line of the boiler; for when the distance between the boiler water line and the low point of the steam main is small, a very small loss of pressure in the steam main will result in the water of the boiler backing up to the air valve and flooding it. Usually, 30 in. is considered the minimum allowable distance between the boiler water line and the lowest point of the steam main, which corresponds to about one pound drop in pressure in the line.

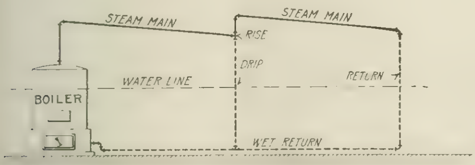


FIG. 3

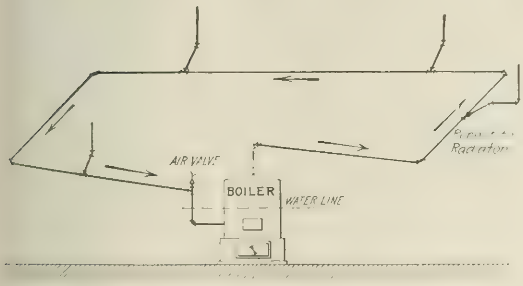


FIG. 4

TWO BASEMENT STEAM-HEATING MAINS

Fig. 3—For low headroom. Fig. 4—Used where headroom is ample for one-way drainage.

It is interesting to note the rise of the return water in a wet return due entirely to drop in pressure, as shown in Fig. 7, where the return stands higher in each return connection as the location becomes more and more remote from the boiler. Near the boiler where the drop is small, the return rises but little above the boiler-water line, but at the end of the system, with one pound loss in pressure, the return will rise about 2.3 ft. and the various other levels will be approximately as illustrated.

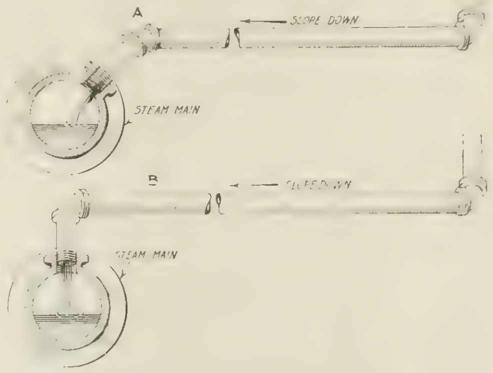


FIG. 5. RISER BRANCHES FROM STEAM MAIN

The formula for checking the size of a steam main carrying radiator condensation has already been stated as $D = \frac{1}{9}\sqrt{R}$, where *D* is the diameter of the pipe in inches and *R* is the number of square feet of equivalent direct radiation.

When the return drops below the water line at the end of the main, it is usually reduced one pipe size.

A second arrangement of piping resembles the circuit main described, but is used for larger systems. This may be termed the "split circuit" arrangement. Usually, if the drop below the water line is made near the boiler, as shown in Fig. 8, the system is spoken of as a split circuit, while if the drop is made at a considerable distance from the boiler, as shown in Fig. 9, it is termed a "wet return" system. Such piping is equally suitable for either one-pipe or two-pipe systems, the one-pipe branches being connected to the steam main as illustrated in Fig. 5, and the two-pipe supply and return branches being connected as illustrated in Fig. 9. Where the two-pipe arrangement is used, the formula for pipe size becomes $D = \frac{1}{10}\sqrt{R}$ instead of $D = \frac{1}{9}\sqrt{R}$, as given for a one-pipe job, thus reducing the diameter of the steam main slightly. The size of

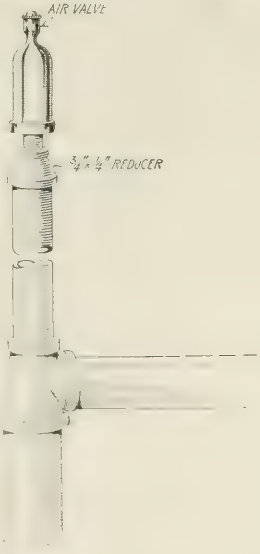


FIG. 6. AIR VENT ON MAIN

the wet return may safely be based on the following schedule:

Sq. Ft. of Equivalent Direct Radiation	Pipe Size
3,000	1¼ in.
6,000	1½ in.
12,000	2 in.
20,000	2½ in.
36,000	3 in.
60,000	3½ in.
80,000	4 in.

It is customary, however, to make a wet return one or two sizes larger than given in the foregoing table in order to allow for partial stoppage by sediment, scale, etc., collecting in this low part of the system. A rough rule is to make the return one-half the diameter of the supply pipe serving the radiation.

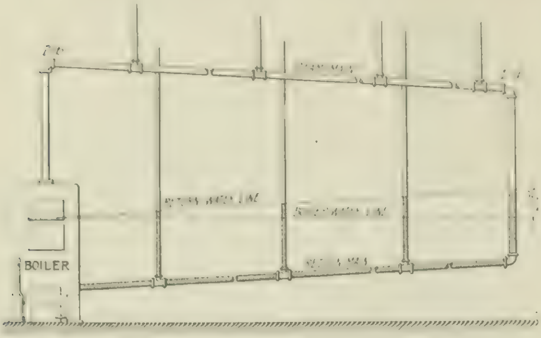


FIG. 7. STEAM PRESSURE DROP PERMITS WATER TO RISE

Difficulty is sometimes encountered with a two-pipe system where one riser or return serves two radiators located directly opposite to each other, one much larger than the other. The larger radiator will sometimes heat only at the ends and will remain cold in the middle part. A typical instance of this kind is illustrated in Fig. 10, where two radiators are supplied by separate risers but both have their returns connected to a common return. When steam is turned into the system (if the bottom of the return riser is water-sealed, as it should be), the steam will enter both radiators at the supply end and will start pushing the air out through the air valves; but because both air valves discharge at the same rate and one radiator is two or three times as large as the other, it follows that the small radiator will be rid of air long before the large one, and the steam then proceeds out through the return connection of the smaller radiator and across through the return connection into the larger radiator at the air-valve end. As soon as the steam comes in contact with the air valve on the large radiator, it shuts off, imprisoning the remaining air in the larger radiator. The best remedy for such trouble is to put in a check valve or a water seal in the return from the large radiator, as shown.

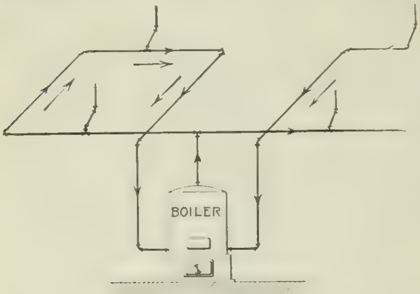


FIG. 8

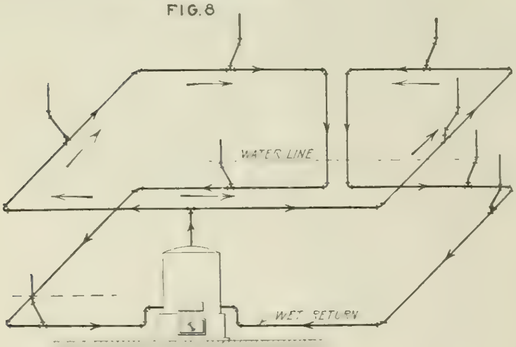


FIG. 9

STEAM MAINS FOR LARGE INSTALLATIONS

Fig. 8—Known as a split circuit. Fig. 9—A wet return.

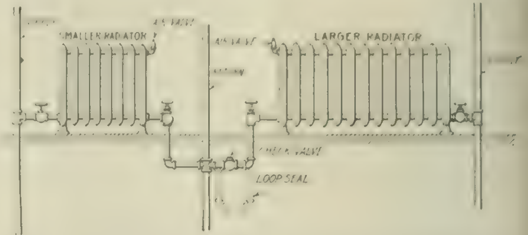


FIG. 10. RADIATOR CONNECTIONS THAT SOMETIMES CAUSE TROUBLE

A common arrangement of steam and return mains is that known as the "dry return" system, illustrated in Fig. 11. It is used almost exclusively for two-pipe systems of heating. This dry return system usually causes the operating engineer a lot of trouble, and its use is warranted only where any other is impossible, but if properly installed it can be made to operate satisfactorily as most of the trouble is due to incorrect methods of piping. Trouble can be avoided by having all connections between the steam main and return water-sealed. The depth of seal required depends on the maximum difference in pressure between the supply and return mains as explained in connection with the rise of water in the return pipe, excepting that in this case the rise occurs in the water seals. Drip connections should never be, but often are, made as shown

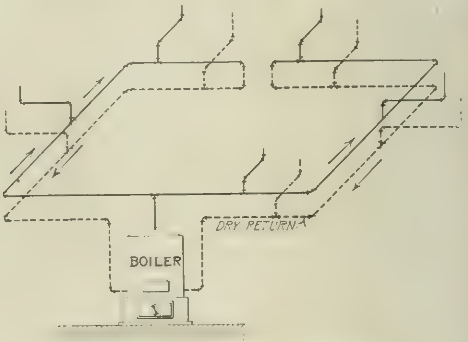


FIG. 11. DRY RETURN SYSTEM

in Fig. 12, as trouble is almost sure to result. These connections should always be sealed by loops, as shown in Fig. 13, or by establishing a false water line in the system. Sealing every connection to a dry return line makes it, as far as operation goes, equal to the wet return. The overhead return may be water-sealed by connecting an "inverted seal" forming a trap of whatever depth of seal is required. This is accomplished by a rise in the line before dropping down to the lower level, as shown in Fig. 14, this rise being connected to the steam line by a balance pipe in order to prevent siphoning.

There is more than one way to operate a gravity steam plant of either the one-pipe or two-pipe design. Many smaller systems are controlled entirely from the boiler room by supplying steam for shorter or longer periods during the day as the severity of the weather demands. For instance, during a period when the outside temperature is around 35 deg. F. steam might be supplied for alternate hours, while with 20-deg. weather it would probably be necessary to keep steam on for two hours and off for one hour, or approximately 67 per cent. of the time on. With zero weather steam would be carried on the system all day, but when the weather moderated again, the "off" periods could be made longer or more frequent to about 60 deg. outside temperature, when there would be little need of artificial heat.

This method, if properly carried out, is one of the most economical ways of running a small plant, as it insures against a waste of heat in unoccupied rooms where radiators—left turned on through carelessness—would cause overheating and waste of coal. The best way to determine the amount of heat required is to select some room of reasonable exposure and easily accessible to the operating engineer at all times. A little experimenting will soon show what temperature this room will heat to by the time all the other rooms have reached 70 deg. F. With this room as a guide, it is comparatively easy—by maintaining the required temperature there as shown by experiment—to maintain a very comfortable temperature throughout all parts of the building.

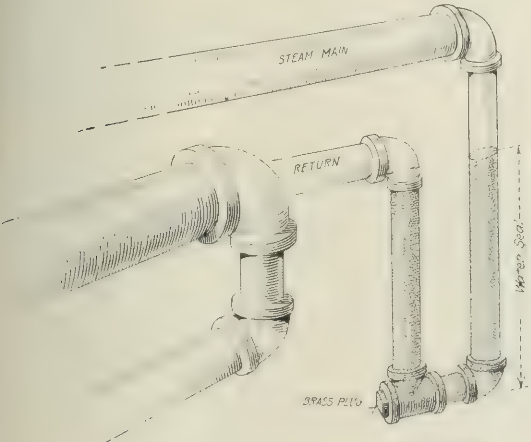


FIG. 12 FIG. 13

RIGHT AND WRONG WAY TO DRAIN HEADERS

Fig. 12—The wrong way. Fig. 13—The right way.

Of course if the radiation is not evenly distributed, the results of trying to operate in this manner will be that some rooms, carrying too much surface, will be overheated while others, with less surface, will be too slow to warm up. The only remedy for this is to readjust the radiator surface until each room has its proportional amount.

Another method is to carry steam pressure at all times, depending upon the occupants to control the radiators so as to maintain desirable temperatures throughout. This method is not usually successful, being subject to abuse by many persons who would always open a window when too warm instead of closing off the supply of heat. If temperature-control apparatus is installed, however, the second method must be used in order to have steam always available when the valves open.

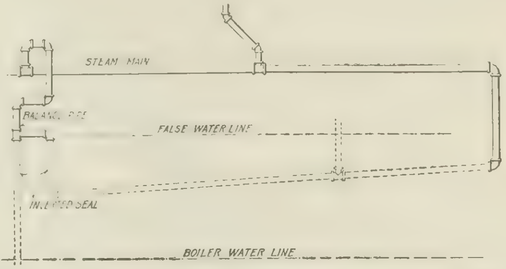


FIG. 11. INVERTED SEAL FORMS FALSE WATER LINE

One suggestion that may help to conserve the coal supply where it is necessary to keep on steam constantly is to place diaphragm valves in any lines that can be shut off for certain periods. In dormitories the heat can be cut off from 12 o'clock midnight to 5 or 6 in the morning without inconvenience and be more healthful for all concerned. In schools the gymnasium, auditorium and other departments in use only a portion of the day are easily shut off at the proper time without affecting the rest of the building.

Canadian Central Stations

The Dominion Bureau of Statistics in coöperation with other departments, has completed a census and directory of the central electric power stations in Canada, including only stations developing electric power for sale.

The capital invested in power stations reaches a total of $356,004,168, of which 79.5 per cent. is invested in commercial stations, and 20.5 per cent. in municipal or publicly owned stations. The total revenue derived from the sale of electrical energy is $44,536,848, of which $29,135,399 was secured by commercial and $15,401,449 by municipal plants. The primary power installation in central stations totals 1,845,161 hp., of which 1,652,661 hp. is derived from water, 180,800 hp. from steam and 11,700 from gas and oil. The actual cost of construction of hydro-electric power stations per installed horsepower (omitting real estate, transmission and distribution equipment) for 70 representative stations throughout Canada with an aggregate turbine installation of 745,797 hp. was $50,740,458, being an average cost of $68.03 per installed turbine horsepower.

Elliott-Ehrhart Jet Condenser

The rapid development of turbine machinery has been paralleled by a like development in condenser apparatus. In fact the turbine, in a large measure, owes its economic position to the high-vacuum condenser. Without the condensing apparatus to maintain the high vacuum requirements, the turbine would not be able to maintain its position.

The condenser as it was known ten or fifteen years ago was not at all suitable for maintaining the high vacuum required by modern turbines, so that the condenser of necessity evolved to its present-day form. The development of condensers has been based on systems that differ materially in their original form, but which have gradually grown toward comparative similarity. Each particular school of design has something to recommend it.

It is a natural development that the designer of a new line of condenser products makes an effort to incorporate in his apparatus those elements which the collective experience of operator, builder and designer have found desirable. This has been done in the instance of the Elliott-Ehrhart jet condenser, manufactured by the Elliott Co., Pittsburgh, Penn., and shown in Fig. 1. It is of the vertical type. Steam enters at the top and the condensing water and products of condensation are pumped out by a centrifugal pump at the bottom of the apparatus (see Figs. 2 and 3). The mixture of steam and water is accomplished by the use of spray nozzles so designed as to break the water into small enough particles to insure a mixture of steam and water without presenting undue resistance to the flow of water. The nozzles are liberal in area, so that ordinary débris in the circulating water will not choke them. The spray nozzles placed in the condenser head are of the helical type, formed by having a twisted division wall located on the inside of the cylindrical nozzles (see Figs. 2 and 3).

The water in passing through the nozzle is given a rotary motion about the axis of the nozzle so that it is torn into very small particles by the centrifugal force of rotation. This design of nozzle has been found to give just the proper amount of centrifugal rotation to the water, tearing it into fine particles.

The openings in the head for inspection and the removal of material that has passed the intake screens, are arranged so that the removal of one nut will give access to the interior. This is accomplished by attaching the cover plate by means of a crab. These openings are placed on the lower surface of the overhanging condenser head, so that the turbine foundations can be bolted close to it. No ground joints are used. Ordinary commercial gasket is the packing, which insures a tight joint when the handhole cover is in place. The centrifugal pump for handling the condensate forms the base of the condenser and has the pump casing split vertically and parallel to its axis, so that the removal of the cover permits the taking out of the shaft in the same manner as with the ordinary horizontally split casing of the centrifugal pump.

The use of the steam ejector for removing air from the condenser system makes the apparatus one of extreme simplicity and efficiency, when it is realized that the exhaust from the ejector may be used for feed-water heating, and thus the maximum B.t.u. are utilized.

Owing to the restrictions of war times the jet condenser has been the first to appear on the market, although surface condensing units are included in the product of the company.

In Texas there is an area having a length of 500 miles and a width of from 50 to 100 miles under which is a bed of lignite estimated to contain about 30 billion tons. This is said to be the largest known deposit of lignite in the United States.

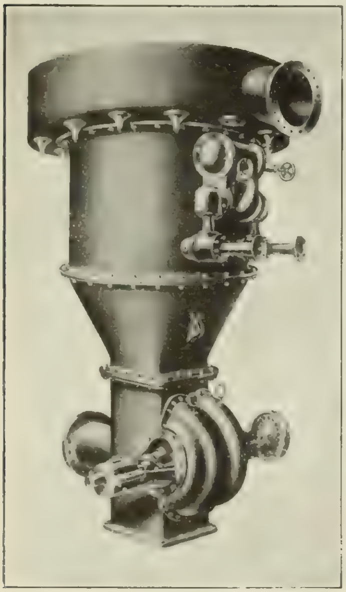


FIG. 1. EXTERIOR OF CONDENSER

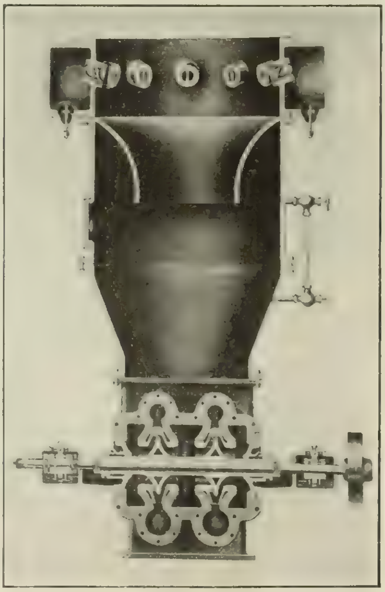


FIG. 2. SECTION THROUGH CONDENSER

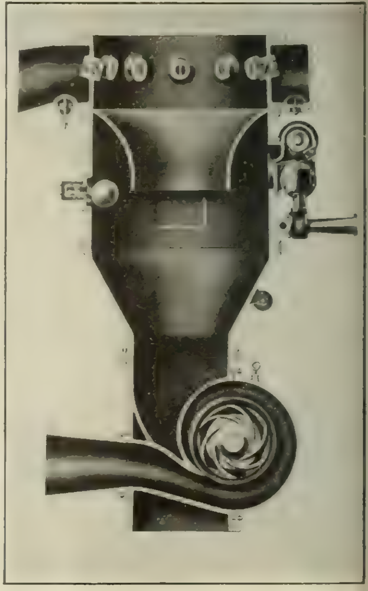
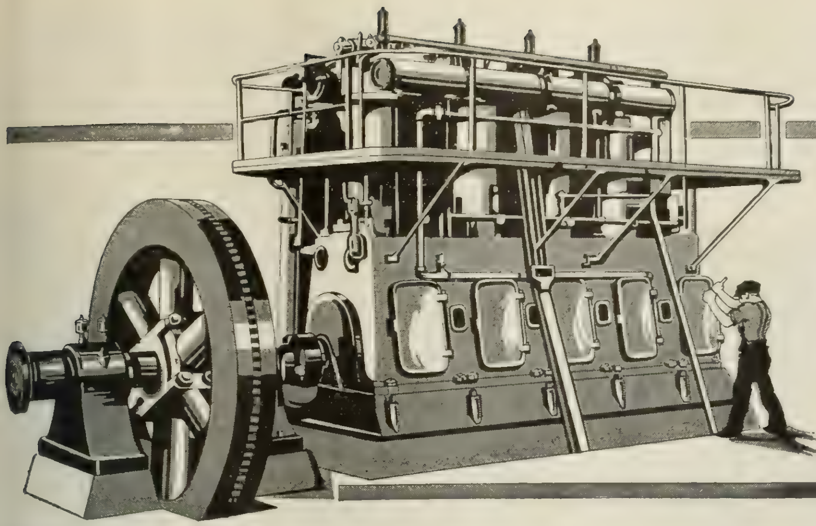


FIG. 3. SIDE SECTIONAL VIEW



Talks on DIESEL Engines

by L. H. Morrison

V—At this meeting the discussion turns to the relative advantages of A frames and box frames, with side remarks on cooling hot bearings.

AT THE following meeting of the class, Egan announced that he intended to take up the discussion of piston and cylinder details, but Woods interposed an objection.

"Before you do that, I wish you'd talk about engine frames," he said. "Last evening I had an argument with Kelly. He says the A frame is lots better than the box frame, and I don't think it is." The young fellow tugged belligerently at a lock of hair that hung over his forehead.

The chief joined in the laugh that followed this declaration of war.

"I can understand Kelly's point of view, and if the old splash system was still used I'd agree with him. But let's hear Kelly's side of the question. I have pictures of both types of frames, built by the same company"—here J. R. displayed the illustrations shown in Figs. 1 and 2—"and so the question of make will not enter into the argument." He turned to Kelly. "What's your objection to the one-piece frame, or box frame?"

"Well," began Kelly, who dearly loved an argument, "the kick I have against the box frame is that it's a box. A fellow's got to crawl through the door if he wants to do any work, and in the crawling he ruins a perfectly good suit of overalls and a sweet and loving disposition. When he does get in, can he do anything? I should say not! He spends all his time wiping the oil out of his hair or off the seat of his pants. Another thing, when the doors are closed, you can't tell where a knock comes from. If it's in a middle crank it always sounds as if it was the end cylinder. If your crank box or main bearing runs hot you never know about it until the engine is about ruined.

"On the other hand, look at the A frame on our 500-hp. engine. Look how easy it is to take out the light sheet-steel covers from between the frames, and then the whole insides is right there. Are you worried if your bearings are warm? Then raise up the cover or slide the little door and put your hand right on the hot place. Do you get your hair full of oil? If you have to take out a crank bearing, it's easy to slide it out between the frames. Me for the A frame!"

"But," said Woods, "Kelly is still talking about a box frame with splash lubrication. From what I've seen of this sort of system, I wouldn't have it on a bet. But at the beginning it was understood that the splash outfit was ruled out. Take the two photos the chief has here. The box frame isn't supplied with a splash, but the bearings have a flood or continuous system of oiling. I'll agree that even with this stream lubrication some oil will be thrown off by the crank, and if the doors are opened while the engine is running somebody will get oiled. But the inspection ports on the box frame are just as serviceable as they are on an A frame. In neither frame can you touch the main bearings by reaching through the handholes or ports. As for getting at the crank brasses or main bearings to remove them—the box frame is much handier. The box is roomier and a man can get inside and have space to lift the brasses. Last Saturday night I helped to take out the No. 2 crank brasses on the A-frame engine, and it was a job. There isn't enough room to raise your back when you start to lift the box, and after you get hold of the box you've got to turn sideways to get it out between the legs of the frame. Now, Mr. Egan, let's hear your views."

The chief paused thoughtfully for a moment before replying:

"I must agree in the main with Woods," he said. "As I stated before, if we must use a splash system, I'm against the box frame. However, this is not necessary, and all builders of box frame have abandoned the splas

"In oil engines, as in ste engines, the tendency to adopt accepted idea design. If the Diesel

At the next meeting piston rings and piston construction will be discussed. Egan will explain to the class the reason for the scoring of cylinders and the sticking of pistons

had originated in America, undoubtedly it would have been built horizontally. You can't deny that horizontal engines are easier to adjust, for all parts are within reach of the floor. Pistons are easier to pull, shafts easier to adjust, and so on. So I say that if the original design had been American, it would have been horizontal, since the American engineer was familiar with horizontal engines. Practically all American firms who have gone into the Diesel game during the past few years, with an American design, have adopted the horizontal frame.

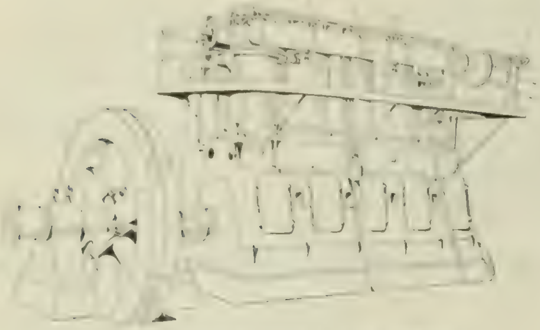


FIG. 1. ENGINE WITH A BOX FRAME

"On the other hand, the European practice was to build vertical steam engines. I presume that the cost of raw materials prompted this since a vertical engine can weigh considerably less than a horizontal. It may have been their desire to produce a longer-lived machine, also a better-balanced one. With these facts in mind, it's easy to understand why the Diesel engine, when first produced, was vertical and why this design still predominates.

"The same reasoning applies to the box and A frame. The A frame can be made lighter in weight than the box, thus reducing the raw-material cost. Against this, the A frame involves more labor cost, but this is cheap in European countries. In designs built under European plans in this country we should not wonder that the A frame predominates. It's noteworthy, however, that the drift of even these builders of the A type is toward the box frame.

"From the viewpoint of operation the box-frame engine is easier to keep in shape. You notice that the A frame on our 500-hp. engine has a tendency to give slightly at the junction of the A flanges and the base. I don't suppose this amounts to more than half a thousandth of an inch, but figure what this means as regards the movement at the cylinder. The base flange is about 18 in. in length. If there is a thousandth of an inch vertical movement at one end with the other edge of the flange as a fulcrum, and the cylinder top is 14 ft. from this flange, the horizontal displacement will be around a hundredth of an inch. This movement occurs to the piston as well. It's easy to see that the brasses will wear out of true—the ends wearing cone-shaped. This may be theory, but I do know our A-frame engine demands more crank adjustment than does our new box-frame engine. As Woods states, the box frame is easier to work in; and if I were buying an engine, I'd insist that the manufacturer put ports in the frame between the doors, so the engineer could see if the bearings were running warm. But I would see that the operator kept these inspection ports closed. I have noticed that some of you boys are in the habit of removing the sheet-steel covers between the A frames and running the engine open. Now, this may help to cool a warm bearing, but the best course is to pay strict attention to your oiling system and so avoid hot boxes. The breathing action of the moving piston sucks air into the frame, carrying with it any dust or grit that may be flying round. To let this grit settle in the engine frame won't help your bearings any. So remember—keep the steel guards on the engine.

'This brings to mind something I saw at the Paducah plant when I visited there last week. A hot bearing had developed on their A-frame engine and some genius had hit on the idea of running a hose line into the oil hole on the bearing cap and was allowing a nice stream of water, as well as oil, to play on the hot shaft. Any engineer ought to know that water used this way will absolutely prevent any oil getting to the shaft, and water itself is a poor lubricant. The water removed some of the heat but produced just as much by its poor lubricating qualities. I suggested to the new chief that he cut out the water and use a heavy stream of oil. When I returned from lunch I found they had discovered a new heat remover. They were then using an air hose from their air compressor and blowing the air on the cast-iron bearing housing. The bad feature of this was that the cooling was occurring from the outside, and if the housing did cool off, it would force the babbitt to grip the hot shaft or squeeze out at the ends. So my advice in case of hot bearings is to avoid water, air or anything except a generous supply of cool oil. Then, when the bearing cools off and the engine can be stopped, inspect the bearings and scrape them if they are in bad shape.

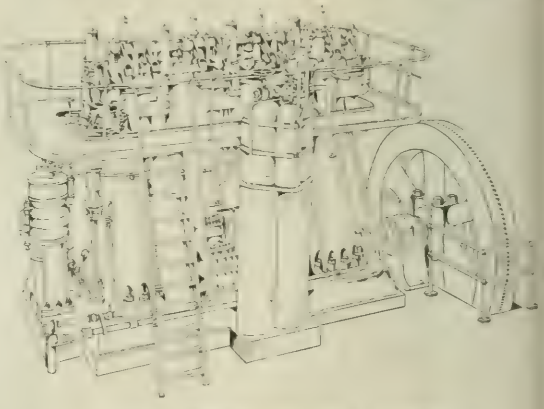


FIG. 2. ENGINE WITH AN A FRAME

"Going back to the frame question, I believe there are only two things that I need mention in regard to operation. One of these is—see that your bolts are always snug. The second and vital one is—keep the frame clean and free from oil leaks and settling dust."

"Chief, since you've mentioned the horizontal engine, I'd like to know which type of horizontal frame you think best from the operator's viewpoint," said Woods.

"There isn't much choice, Woods," Egan replied.

'You'll find practically all builders use a one-piece frame, as in Fig. 3, with the cylinder water-jacket cast in one piece with the frame and using a center-crank shaft. This makes a rigid construction and simplifies the manufacture. It also eliminates any danger of broken bolts between cylinder flange and engine frame.

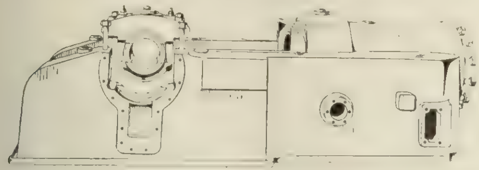


FIG. 3. ONE-PIECE FRAME FOR A HORIZONTAL ENGINE

"Fig. 3 is a fairly representative type of horizontal frame, this design being followed by practically all builders, except as to minor details. The chief feature of this type is its heavy weight. The majority of builders still adhere to the trunk piston. A few make use of the crosshead type, and consequently this latter engine has a frame considerably longer than the former.

"In operation the horizontal frame allows the engineer to have easy access to all parts, and it is easier to dismantle and adjust. In sizes up to 300 hp. I think it ideal. Going to larger sizes, we find all builders using the twin engine design, having the flywheel and generator between the two frames. In this case the unit is made up of two distinct engines. Frequently each engine has its separate governing mechanism. In operating such a unit on a lighting circuit, there is likely to be trouble with flickering of the lights. It seems practically impossible to make the action of the two units synchronize.

"If the load demands an engine capacity above 200 hp. and the horizontal type is decided upon, by all means insist on two separate engine-generator units."

"I can't get your argument, J. R.," Woods said. "Why will this help matters if the engines don't synchronize?"

"But you've forgotten the fact that we are now figuring on two generators. If the generators are equipped with damping windings, the tendency to fall out of step is practically destroyed.

"Another important item to consider is the available room space. The horizontal units in large sizes demand much greater floor space than the vertical engine, and ordinarily floor space is of more moment than headroom, unless the outfit is installed in a basement."

Conditions in the Power Industry

BY L. W. ALWYN-SCHMIDT

A digest of the reports of United States consuls on the power situation in various parts of the world and the influence of the war upon this important industry. Also see "Power," Dec. 3, 1918.

POWER conservation is still agitating the minds of English engineers and the coal controller has appointed four hundred experts to consult with and advise power users with a view to reducing the waste of power and coal. The Coal Control Technical Committee believes that there is in England a tremendous waste of coal and that it can be eliminated; but to change the situation will take several years. The advisory work, therefore, will be continued during peace until the installation of more efficient power plants is guaranteed. The English government seems to be of the opinion that unskilled handling of the power plants—especially the employment of many unskilled stokers—has a good deal to do with the wasteful habits complained of. More than 45,000 firms will be examined, only 364 of which so far have been visited, and it is estimated that a saving of 106,000 tons of coal will result from this work alone.

To make possible a more effective control of the consumption end of the coal-conservation scheme in England, it became necessary some time ago for the coal controller to take the leading gas works under his jurisdiction. So the Bristol Gas Co. was operated under the administration of the controller. It appears that the gas works had to assume a good deal of the load generally carried by the electrical power plant in Bristol, by supplying a larger share of the lighting facilities. The electrical plant was compelled to increase its supply facilities considerably so as to be able to deliver enough power to local industries. It is interesting to note that more than 80 per cent. of all the electrical energy produced by the municipal power plant in Bristol was taken up by industrial enterprises.

Following the precedent of other cities, Glasgow has been compelled to add to its local power supply. The general plan for this extension was made before the war and work had been started in 1914, but it was suspended at the outbreak of the war. The unexpected increase in the demand for power later made it advisable to resume construction, which was done in 1916. The site of the new station is at Dalmarnock, Scotland, and covers 45 acres on the right bank of the River Clyde. Four 25,000-hp. turbo-alternators will be installed, together with eight boilers. There will be a complete plant for handling the coal, for which there is a storage system having a capacity of 60,000 tons.

England also has given much attention to the question of providing power in India. Attempts are being made to store the waters of the monsoon and use them for hydro-electric power development. There are large parts of India which have a rainfall for three months, and during the remainder of the year the rivers dry up or run so low that no effective use can be made of them for power development. It is now contemplated to use convenient valleys to form reservoirs. The Tata hydro-electric scheme is of this character. It is expected that by erecting a series of dams enough water can be provided for creating 100,000 horsepower (C. R. 231).[1]

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[1] C. R. indicates "Commerce Reports" of 1918.

The increasing supply of energy at cheap rates to the cities and villages of Switzerland has created a considerable demand for electric motors. The Swiss government kept a sharp watch on the development of the electrical power industry in Switzerland during the war and large electrical machines could not be sold or delivered without its permission. The demand for motors will grow as there is a factory of some kind in almost every village (S. C. R. 17b).[3]

ELECTRIFICATION OF SWISS RAILROADS COMPLETED

The demand for electrical power in Switzerland will be strengthened by the now seriously contemplated electrification of the Swiss railroads. The serious coal shortage that has overtaken Switzerland as the result of the war now seems to have forced the hand of the government, and a close investigation has been made of all the factors that might influence the early development of the scheme. Pre-war estimates had put the cost of such an enterprise at approximately $100,000,000, excluding the purchase of the electric locomotives. Taking into consideration the increased price of all railroad material and electrical equipment, it is now expected that the enterprise cannot be completed much below $150,000,000. As it is contemplated to proceed slowly, this expense can be distributed over a period of approximately 30 years.

The amount of water power required has been estimated at 200,000 hp. at the axis of the turbines, with a momentary maximum of 600,000 hp. Concessions have been secured for obtaining the required power at several rivers. Other power sites will be acquired and it is expected that 150,000 hp. at the turbines can be obtained, which will be sufficient for three-quarters of the system. Additional power may be secured in coöperation with municipal power stations. The cost of the locomotives is estimated at $90,000,000. On the present basis Switzerland will spend annually $5,000,000 for electrifying the existing system, $800,000 for new electrical lines, $7,200,000 for works of completion and $5,400,000 for rolling stock, making a grand total of $18,400,000 every year.

Vice Consul R. E. Schoenfeld in Berne, in forwarding this news, adds that the Swiss government sees great difficulties in financing the project in Switzerland and that rumors have been published in the Swiss press that the money, or a large part of it, might be obtained in the United States. These rumors so far have been neither confirmed nor contradicted. If the United States should be induced to provide the means for this vast enterprise, it is to be expected that much of the electrical equipment would be supplied by this country (C. R. 262).

ELECTRICAL SALT EXTRACTION IN NORWAY

Where electrical power is cheap, as in Norway, there will be always a tendency to broaden its application. Experiments were made in that country with a view to extracting salt from sea water by electrical means. These proved successful, and it is now intended to build two salt-extracting factories, one in the west and one in the north of Norway. Each factory is expected to produce 50,000 tons of salt per year. The cost of the undertaking will amount to $5,360,000, and 6500 hp will be required in each instance (C. R. 240).

Brazil, which has made great industrial progress during recent years, is dependent on imports for a large part of its fuel, and in 1913 more than 2,530,000 metric tons of coal was imported. This import was cut by the war to 877,000 tons in 1917. Naturally, Brazil has felt the situation acutely and coal prices have become practically prohibitive. The Brazilian coal deposits are not always located conveniently for transportation and so are of use only to comparatively small districts. During the war much wood was burned to replace coal.

To solve its fuel problem completely, Brazil will have to make an extensive use of its dormant natural powers. There are great hydro-electric possibilities along the Rio Grande, Tiete, Parana, Paranapanema and Picaicaba. Government engineers have estimated that 1,876,300 hp. can be generated from the principal waterfalls of the State of Sao Paulo alone. The City of Sao Paulo has a hydro-electric central station that supplies power to the industrial enterprises in the city and its neighborhood. The question of placing great central stations in the coal-mining districts and distributing the power by high-tension transmission lines does not seem to have been considered yet.

AMERICAN ELECTRIC-STATION EQUIPMENT IN SOUTH AMERICA

American electric-station equipment is gaining ground in South America. The two power stations in the City of Valencia, Venezuela, are both equipped completely with American power machinery, as is the tramway company of the same city. The first of these power companies has a capital of $270,000, and the other is capitalized at $154,400. Both are under the control of Venezuelan interests. The power is generated with the assistance of waterfalls near the city. The first-named undertaking supplies the power for the local tramway enterprise. The demand for electrical power has grown very rapidly in the city, and it will soon become necessary to add to the existing facilities by tapping other falls in the vicinity (C. R. 260).

The very satisfactory condition of the New Zealand electrical power industry can be judged from the report for 1918 of the Wellington Electric Light and Power Plant, an enterprise under municipal control. On a total capital investment of $1,071,300 a net profit of $141,707 was made, or 13 per cent. This was obtained after deducting interest on loans, public and private lighting, depreciation, etc. On Mar. 31, 1918, there had been made 10,384 lighting connections, as against 9454 on the same date the year before; further, there had been made 4878 heating connections against 4003, and 378 power connections against 362, or a total gain of 1821 connections. The enterprise had great difficulty in securing the supplies required for upkeep and extension of the service (C. R. 233).

At some day not far distant the seven nations of humanity will unite and blend like the seven colors of the prism into one celestial radiant whole, and beneath the majestic rainbow of the "United People of Europe" the enraptured world will dwell forever lapped in the miracle of eternal peace.—*Victor Hugo* in 1852.

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[3] S. C. R. indicates "Supplement, Commerce Reports."

Yarway Automatic Boiler Skimmer

When water is brought to the boiling point in a vessel, more or less scum will float on the surface, depending upon the character of the water. When the water is used for boiler feed, if this floating material is not removed, it soon settles and becomes attached to the shell and tubes of the boiler and trouble with scale results.

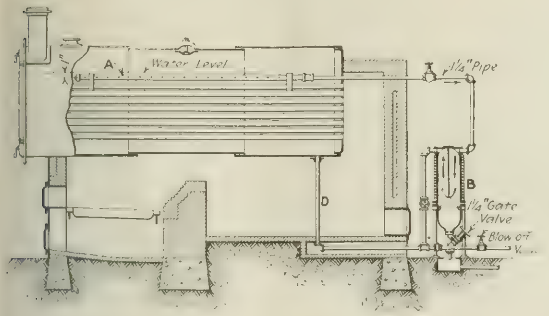


FIG. 1. SKIMMER APPLIED TO A RETURN-TUBULAR BOILER

Several types of surface blowoffs have been devised to remove this floating scum, one of which is the Yarway automatic boiler skimmer, made by the Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn. This skimmer consists essentially of two parts: The skimmer pipe, placed in the boiler; and the precipitator, placed on the outside of the boiler, and in which the scum and sediment are separated from the water.

Various designs of skimmers are provided, suited to different types of boilers. In Fig. 1 is shown the skimmer as applied to a return-tubular boiler. This skimmer consists of a 1¼-in. pipe *A* perforated with small holes along the top and sides. This pipe is supported horizontally about ½ in. below the normal water line. It connects to a pipe of the same size which communicates with the inlet connection of the collector *B*, which is divided by a baffle plate. A return pipe connects the outlet of the collector with the boiler by means of the blowoff pipe *D*.

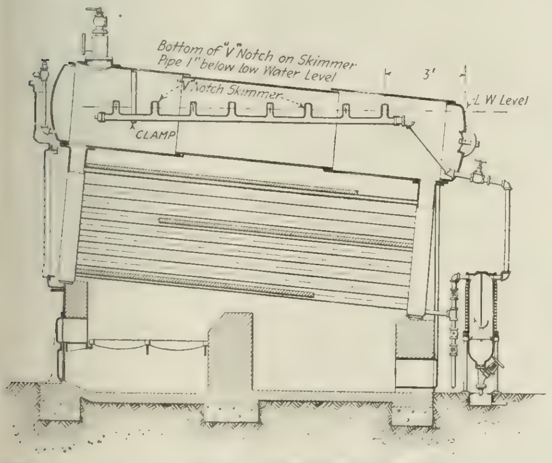

Bottom of "V" Notch on Skimmer Pipe 1" below low Water Level
3'
"V" Notch Skimmer
L W Level
CLAMP

FIG. 2. ARRANGEMENT OF SKIMMER IN WATER-TUBE BOILER

The action of the skimmer is as follows: When the boiler is in operation, the difference between the temperature of the water in the boiler and that in the collector starts a siphonic action and sets up a circulation through the skimmer in the direction of the arrow.

As the water circulating in the boiler sweeps past the holes in the skimmer pipe, a portion is drawn into the circulating pipe, carrying scum and sediment with it over into the collector. As the water descends it strikes a deflecting cone and passes upward on the other side of the deflecting plate.

As the velocity of the water is greatly reduced during its passage through the collector, because of its large area, the heavier sediment settles to the bottom of the chamber below the deflecting cone, where there is no flow, and the water returns to the boiler without the impurities.

When the skimmer is used with water-tube and vertical fire-tube boilers, the design of the skimmer is different, as the headroom in the drum of the one and the upper portion of the shell in the other type of boiler permit of the use of V-notch tubes, as shown in Figs. 2 and 3. This design of skimmer consists of a cast-iron skimmer head, and each vertical pipe is made with a V-notch opening on one side only, and the pipes are arranged so that the V-notch openings alternate, thus permitting scum from both sides of the skimmer to be drawn into the pipe and circulated through the collector.

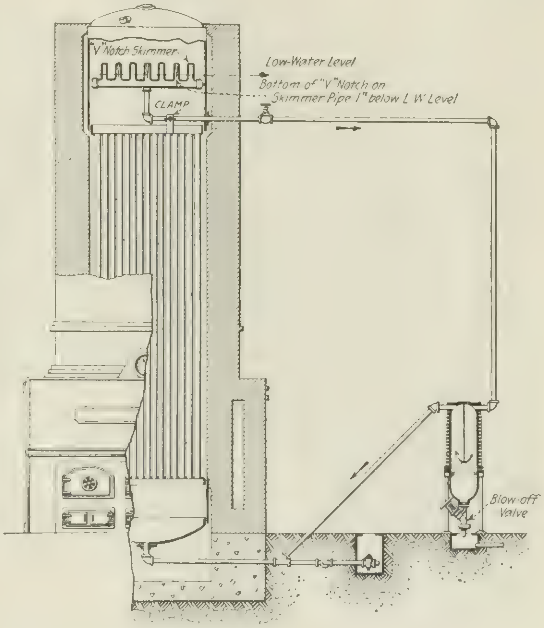


FIG. 3. SKIMMER USED WITH VERTICAL BOILER

In the skimmer used with a vertical boiler the V-notch tubes are arranged as arms spaced 90 deg. as shown in Fig. 3. These vertical tubes are so placed in the boiler that the bottoms of the V-notches are one inch below the low-water level.

The operation of the skimmer in all installations is the same as with the return-tubular boiler.

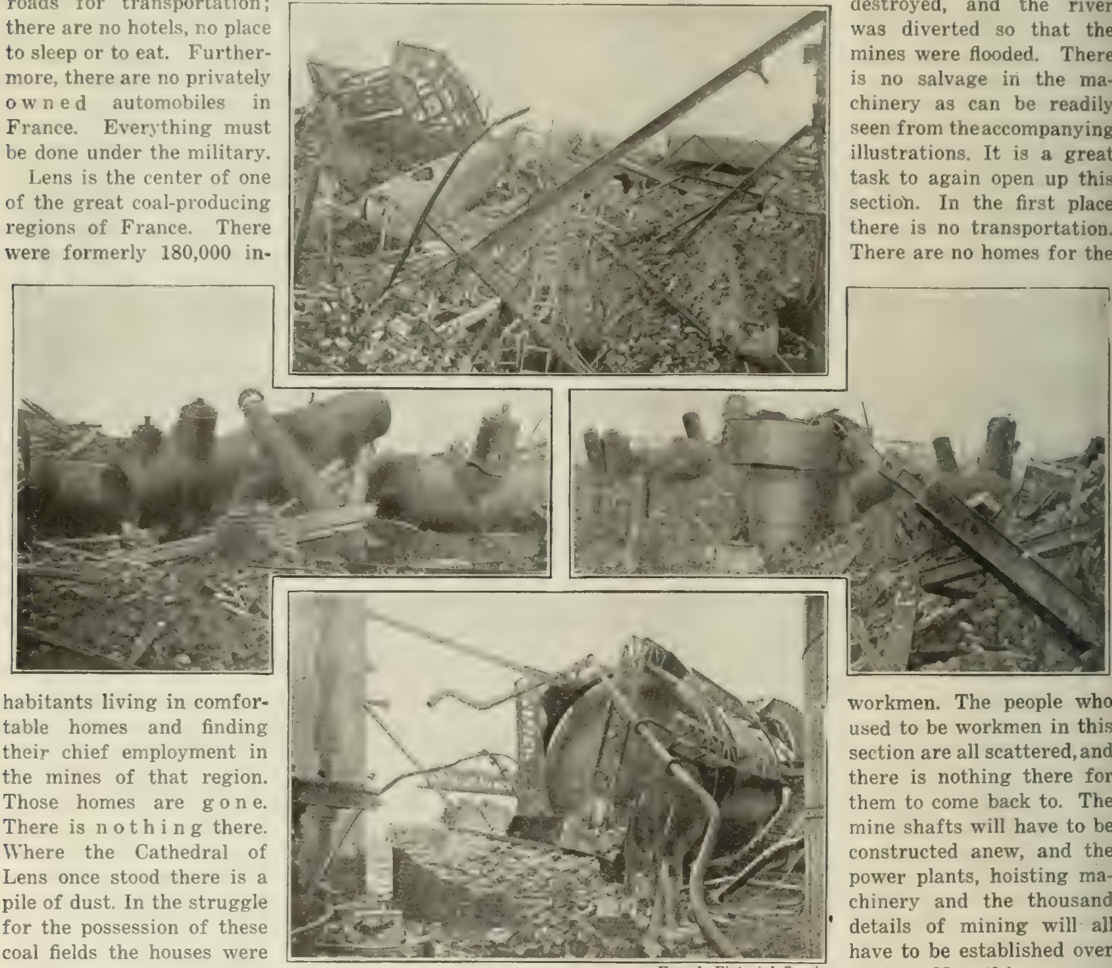
The Ruined Coal Mines of Lens

BY

ARTHUR J. BALDWIN

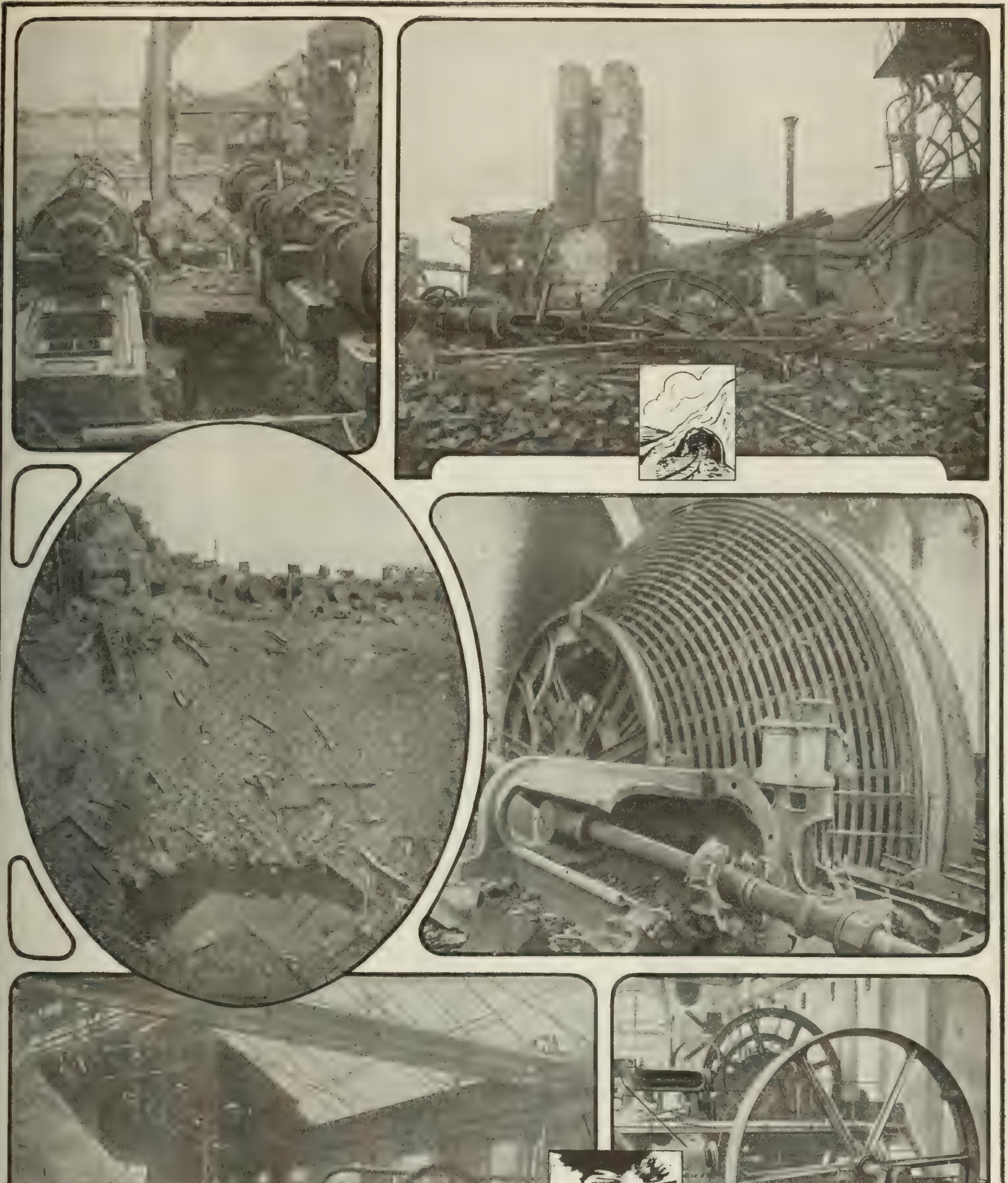
I HAVE seen Lens. At least, I have seen where Lens used to be. I was in Europe when the armistice was signed. Through the courtesy of the General Staff of the British Army and as a guest of the British Ministry of Information, I was taken over the battlefields immediately following the enforced retirement of the German army. The devastated area of France is indescribable. It is impossible to see this except under government auspices. There are no railroads for transportation; there are no hotels, no place to sleep or to eat. Furthermore, there are no privately owned automobiles in France. Everything must be done under the military.

Lens is the center of one of the great coal-producing regions of France. There were formerly 180,000 inhabitants living in comfortable homes and finding their chief employment in the mines of that region. Those homes are gone. There is nothing there. Where the Cathedral of Lens once stood there is a pile of dust. In the struggle for the possession of these coal fields the houses were used by the Germans as shelter. The soldiers were billeted in the cellars. The ruined walls furnished concealment to German batteries. German pillboxes of solid concrete were built near the shattered ruins in the hope of concealing their location by the general devastation about them. This occupation caused a continuous rain of shells from heavy guns of all caliber until the very city has been wiped from existence and nothing is left excepting piles of brick and stone and dust and timber. What was not destroyed by the English in the bombardment was obliterated by the Germans before they left. Power plants were blown up, mine shafts were destroyed, heavy charges of explosives were let loose at great depth in the mines so that the underground workings were destroyed, and the river was diverted so that the mines were flooded. There is no salvage in the machinery as can be readily seen from the accompanying illustrations. It is a great task to again open up this section. In the first place there is no transportation. There are no homes for the workmen. The people who used to be workmen in this section are all scattered, and there is nothing there for them to come back to. The mine shafts will have to be constructed anew, and the power plants, hoisting machinery and the thousand details of mining will all have to be established over again. Not this year or next, nor within the next three years, will it be possible to obtain a pound of coal for the industries of France from this region.



French Pictorial Service

The pictures show all that was left of the power plants of some of the mine heads.



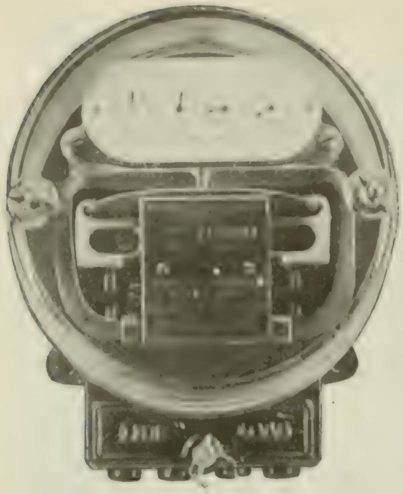
French Pictorial Service

THE ACCOMPLISHMENT OF DELIBERATE FRIGHTFULNESS. COMPLETE DESTRUCTION

Testing Single-Phase Watt-Hour Meters Using a Rotating Standard

by

P. B. Findley



The construction of the rotating standard wattmeter is described and its application to testing single-phase watt-hour meters discussed.

A ROTATING standard is simply a watt-hour meter having a pointer on the upper end of its shaft and arranged so as to operate on a number of currents and voltage combinations by turning a switch. Inherently, its accuracy is not as permanent as that of a wattmeter, so that if in constant use it should be calibrated at least once a month. If used intermittently it will retain its accuracy much longer. For the industrial plant the best arrangement would be to have the calibrating done by the manufacturer before the periodic tests of the service meters, say every six months. In Fig. 2 is shown a single-phase rotating standard. *P* and *P* are the potential-coil terminals, *C* and *C* the current-coil terminals and *S* the switch for connecting the meter element for different current values. The large hand *H* is connected directly to the meter shaft, consequently rotates at the same speed. The small hand *h* is geared to the large hand in such a ratio that for one revolution of the latter the former moves one division, therefore the small hand indicates the number of complete revolutions made by hand *H*. The fraction of a revolution made by the large hand is read directly from the large scale, which is divided into 100 equal parts, hence can be accurately read to 0.01 part of a revolution.

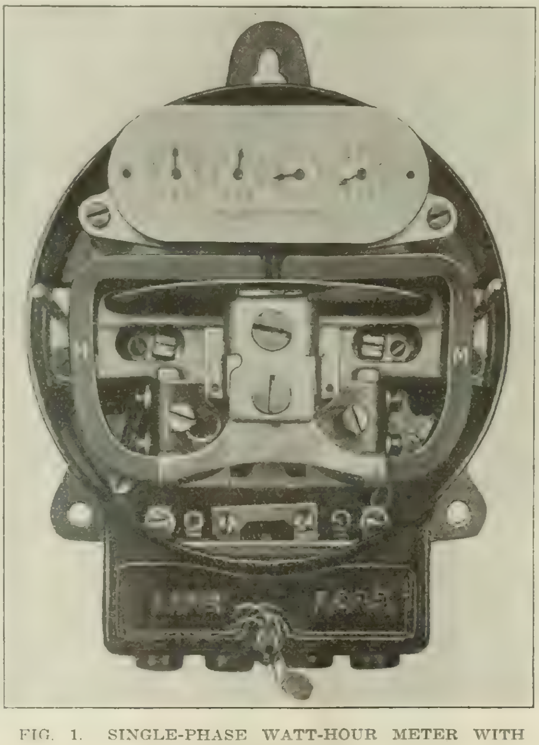


FIG. 1. SINGLE-PHASE WATT-HOUR METER WITH COVER REMOVED

Fig. 3 is a view of the meter element of the rotating standard shown in Fig. 2. It can be seen that the disk *D* and permanent magnets *M* are similar to those used in the single-phase meter, Fig. 1, which is the instrument described in the article, "Testing Single-Phase Watt-Hour Meters Using an Indicating Wattmeter," in the Jan. 28 issue. The push-button *B*, Fig. 3, connected to the meter through a flexible cord, is used to control the starting and stopping of the instrument when making a test of the service meter. In making a test on a watt-hour meter the first thing to do is to inspect the meter to see that it is in the proper operating condition as outlined in the article referred to, then the number of revolutions that the service meter will make at the different test loads is determined. When the watt-hour constant K_h of the service meter has been found, the speed N for a load of P watts is $N = \frac{P}{60K_h}$. In order to simplify construction, most manufacturers build all sizes of meters for the same full-load speed; in the case of the alternating-current meters under consideration this is 25 r.p.m. All rotating standards should have a push-button *B* connected by a long flexible two-

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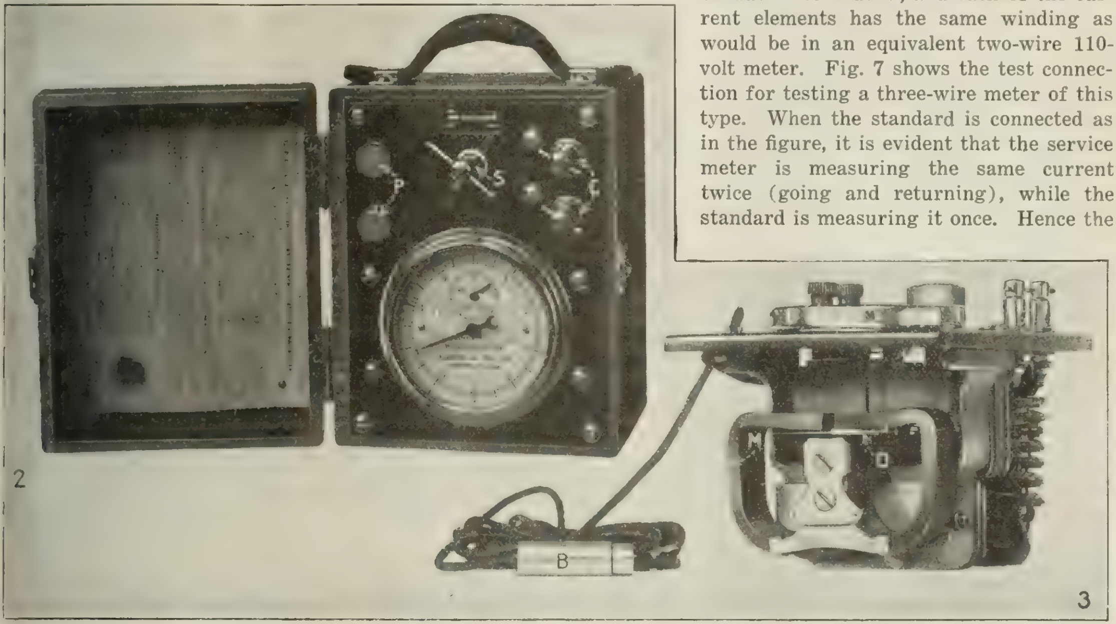
Note. The concluding words in the title to the article on Testing Single-Phase Watt-Hour Meters in last week's *Power* should have read "Using an Indicating Wattmeter."—Editor.

conductor cord in the voltage circuit, as in Fig. 3. This allows the meter to be started and stopped while the tester is observing the disk of the service meter. In making a test on a service meter the pointer of the standard is set to zero, and when a mark on the disk of the service meter passes a point such as the tip of one of the magnets, the button is pressed and the rotating standard started. When a specified number of revolutions of the service-meter disk is completed, the button is released and the standard stops. The error of the service meter is then $E = \frac{N \times 100}{M} - 100$, where E = per cent. error of service meter, N = revolutions of service meter, and M = revolutions of standard meter.

The foregoing formula is true only when the two meters are rated at the same speed for equal loads. Thus all Westinghouse alternating-current meters run at 25 r.p.m. at rated load: for example, a 10-ampere 200-volt service meter runs 25 r.p.m. at 2000 watts; a rotating standard meter connected for 40 amperes 100 volts runs 25 r.p.m. at 4000 watts. When it is necessary to use standard and service meters that have different speeds at equal loads, the simplest way is to employ a conversion table furnished by the manufacturers of the standard meter.



FIGS. 2 AND 3. SINGLE-PHASE ROTATING STANDARD COMPLETE AND METER ELEMENT FOR SAME

The simplest form of meter to test is one that is self-contained, that is, uses no transformers. Typical connection diagrams are given in Figs 4, 5, 6 and 7. Fig. 4 shows the connections for testing the type of single-phase watt-hour meter under consideration in sizes of 5 to 80 amperes. In single-phase watt-hour meters of 100-ampere capacity and up to 300-ampere, one of the potential-coil connections is made outside the meter, as in Fig. 5.

The basic principle is of course to connect the current coil of the standard in series with those of the service meter and the voltage coil across the line outside the service meter, as indicated in the figures. Connections should be transposed if necessary so that the standard meter runs forward; otherwise its friction compensation will act against rotation and make it run slow.

A three-wire meter has four current coils; that is, each of the current coils of the two-wire type is split, one-half of each being in each outer wire. The voltage coil is connected across the outer wires, not from one wire to neutral, as in the direct-current meters. Hence a meter of this type is tested as a two-wire meter. Fig. 6 gives the connections for testing a three-wire single-phase watt-hour meter with a rotating standard. It will be seen that these connections are the same as those for the two-wire meter in Fig. 4.

Some types of three-wire single-phase watt-hour meters have the voltage coil connected from one outside conductor to neutral, and each of the current elements has the same winding as would be in an equivalent two-wire 110-volt meter. Fig. 7 shows the test connection for testing a three-wire meter of this type. When the standard is connected as in the figure, it is evident that the service meter is measuring the same current twice (going and returning), while the standard is measuring it once. Hence the service meter will rotate about twice as fast as the standard meter, and therefore its revolutions should be divided by 2 before comparing with the standard. When using the formulas involving K_h, care should be taken that this value represents the watt-hours measured by the combination of the voltage coil and one current coil. Since the difference between the right and wrong values is 2:1, a rough test will show whether the value used is correct or whether it should be doubled or halved.

Current and potential transformers are used with meters when either quantity is too large to handle with convenience or safety in the confined space of a meter mechanism. The transformers become parts of the instrument as far as accuracy is concerned, and hence their error must be taken into account. This can best be done by calibrating the entire group as a unit. For voltages up to 220, and sometimes to 550, the potential transformers are omitted. The portable transformers connected to the standard meter are very accurate, and are supplied with correction data, which should be used to correct the reading of the rotating standard before applying it to determine the accuracy of the service installation.

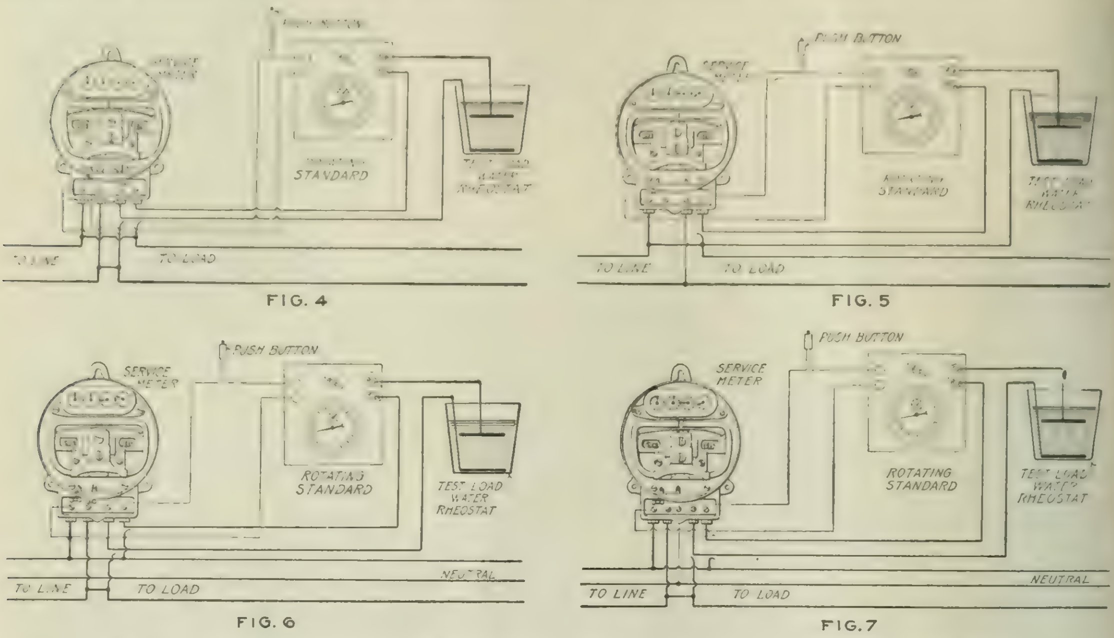
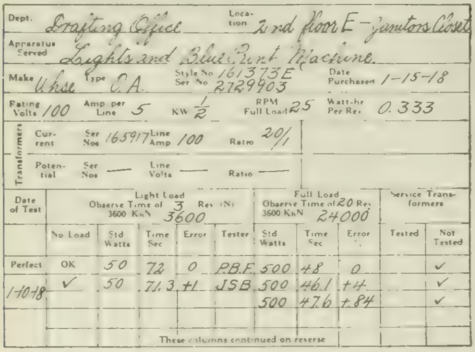


FIG. 4 FIG. 5 FIG. 6 FIG. 7

FIGS. 4 TO 7. DIAGRAMS OF CONNECTIONS FOR TESTING SINGLE-PHASE WATT-HOUR METERS

The permanency of instrument transformers is so high that with good usage the ratio can be relied on for five years without rechecking. Good usage means that they are not overloaded, that the current transformer secondary is always short-circuited unless connected through an instrument, as long as the primary is carrying current, and that no severe line short-circuits have occurred. If these conditions are met, it is practicable to test service meters by connecting the standard in circuit with the meter alone.



Dept. Drafting Office Location 2nd floor E—Janitors Closet
Apparatus Served Lights and Blue Print Machine
Make Whse Type O.A. Style No 161373E Ser No 2729903 Date Purchased 1-15-18
Rating Volts 100 Amp per Line 5 KW $\frac{1}{2}$ RPM Full Load 25 Watt-hr Per Rev 0.333
Transformers Current Ser Nos 165917 Line Amp 100 Ratio 20/1
Potential Ser Nos — Line Volts — Ratio —

Date of Test	Light Load Observe Time of 3 Rev (N) 3600 KhN 3600					Full Load Observe Time of 20 Rev 3600 KhN 24000			Service Transformers	
	No Load	Std Watts	Time Sec	Error	Tester	Std Watts	Time Sec	Error %	Tested	Not Tested
Perfect	OK	50	72	0	P.B.F.	500	48	0		✓
1-10-18	✓	50	71.3	+1	JSB	500	46.1	+4		✓
						500	47.6	+.84		✓

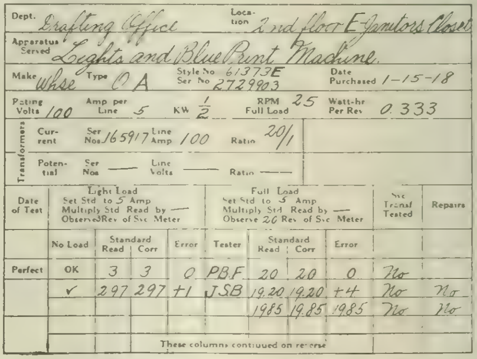
These columns continued on reverse

FIG. 8. WATT-HOUR METER RECORD CARD WHEN TESTING WITH INDICATING WATTMETER

When a meter on a high-tension circuit is to be tested, its potential coil can be energized from its transformer, as in service. Its current supply, however, can be obtained from a step-down transformer, whose secondary gives about 110 volts. This method is used where the connected load is not suitable in amount or steadiness, since an artificial, rheostatic, load is difficult to arrange for voltages above 220.

Since single-phase three-wire distribution is rarely used except on 110- to 220-volt service, potential transformers are not used. Current transformers, however, may be used for heavy currents. Sometimes a single current transformer with two primaries and one secondary is used, but the testing circuit is virtually the same.

Tests at low power factors need rarely be made of meters in service, unless the connected load furnishes a suitable load. Occasionally, however, such a test must be made. For routine testing of this sort, usually the voltage is thrown out of phase by a phase-shifting transformer. This transformer has primary windings for two- or three-phase supply and a movable secondary winding that can be shifted so as to bring it part way between the primary windings. Thus the phase of the current winding's voltage will lie between that of the



Dept. Drafting Office Location 2nd floor E—Janitors Closet
Apparatus Served Lights and Blue Print Machine.
Make Whse Type O A Style No 61373E Ser No 2729903 Date Purchased 1-15-18
Rating Volts 100 Amp per Line 5 KW $\frac{1}{2}$ RPM Full Load 25 Watt-hr Per Rev 0.333
Transformers Current Ser Nos 165917 Line Amp 100 Ratio 20/1
Potential Ser Nos — Line Volts — Ratio —

Date of Test	Light Load Set Std to 5 Amp Multiply Std Read by — Observe 3 Rev of Svc Meter					Full Load Set Std to 5 Amp Multiply Std Read by — Observe 20 Rev of Svc Meter			Svc Transf Tested	Repairs
	No Load	Standard Read	Standard Corr	Error	Tester	Standard Read	Standard Corr	Error		
Perfect	OK	3	3	0	PBF	20	20	0	No	
	✓	297	297	+1	JSB	19.20	19.20	+4	No	No
						1985	19.85	1985	No	No

These columns continued on reverse

FIG. 9. WATT-HOUR METER RECORD CARD WHEN TESTING WITH ROTATING STANDARD

primaries, as desired. In testing single-phase watt-hour meters, the following points should be borne in mind:

The secondary of every current transformer should be short-circuited at all times except when it is connected through the current-coil of an instrument.

To test a service meter, connect the potential coil of the indicating, wattmeter or rotating standard across the points where the voltage coil of the service meter is connected, and the current coil of the test instrument in series with the current connections of the service meter. If connection is made on the line side of the instrument transformers, the service-meter adjustment will compensate for transformer error.

Before taking readings make sure that all rotating instruments turn forward.

Make sure before making any adjustments that the conditions found are not due to any of the following causes:

Condition Found	Probable Cause
Slow on full or light loads	Short-circuit in current or potential coils
Slow on light load	Defective bearing; excessive friction in register train
Fast on full or light loads	Weakened magnets; short-circuit in external reactance in potential circuit (if used)
Will not run	Bent shaft or disk; open potential or current coil

Tests of single-phase meters should be made periodically, at least as often as the following schedule: Up to and including 25-ampere capacity, once every 36 months; above 25-ampere capacity, once every 24 months. Where vibration is severe or high accuracy is important, tests should be made as often as every month. A record card for each meter similar to that shown in Figs. 8 and 9, will be found very useful in keeping track of meter performance.

Meter manufacturers have experts on the road to assist users in getting the best possible service from their meters. In a day's time spent with one of these experts, the isolated-plant man can pick up enough practical points applying to his own installation to be able to take care of any ordinary maintenance. Bad cases such as burnouts, short- and open-circuits, should in general be returned to the manufacturer for repair and recalibration.

There is a large demand for electrical power in central Texas close to the Texas lignite beds. Water is rarely present in sufficient quantities for condensing purposes in connection with steam-turbine power plants in these regions. It looks as though the future supply of power for central Texas must come from lignite, used in the raw state in by-product producer-gas plants, as carbonized lignite on automatic stokers under boilers or in power-gas producers, or in a gas engine as surplus gas from the carbonizing process to which the lignite is subjected.

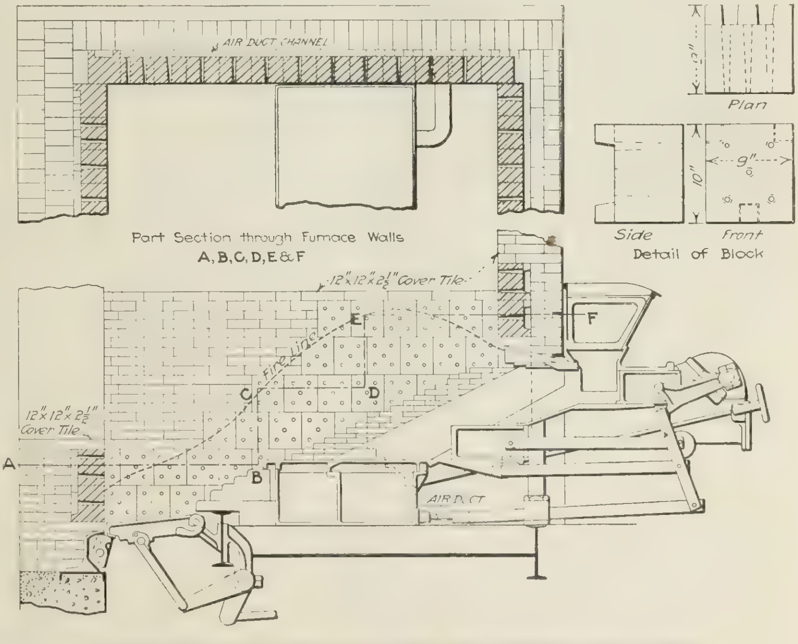
Drake Nonclinkering Furnace Blocks

Not only is it good engineering to so design a boiler furnace that the most economical combustion of the coal can be obtained, but the item of upkeep should not be overlooked. Every engineer and fireman know that considerable trouble is caused by clinkers forming on the side walls and on the front of the bridge-wall. If these are left attached to the brickwork the area of the furnace is reduced, and if the clinkers are knocked off the brickwork will be injured.

There have been several methods employed for the introduction of air at the fire level for the purpose of cooling the brickwork at that point and so preventing ashes from fusing and sticking to the furnace lining. In the method employed by Sleicher & Drake, 5 Beekman St., New York City, special firebricks are used in the furnace construction, each 9 x 10 in. on the face, and 9 in. from the face to the outside surface of the three lugs on the back of each block. These lugs form an air duct, from which air is supplied to the five tapered holes in each block.

Not only are these blocks used in the side walls, but they are also placed in the setting at the front of the furnace above the fire and at the rear end of the furnace, in the bridge-wall. An air duct connects a windbox with the air-duct chamber at the back of the perforated blocks, and through these channels air is supplied to the openings in the blocks. A damper permits of regulating the air supply to suit conditions. The illustration shows how the blocks are installed, and details of their construction are given. The top of the air-duct channel is sealed by cover tile 2½ in. thick.

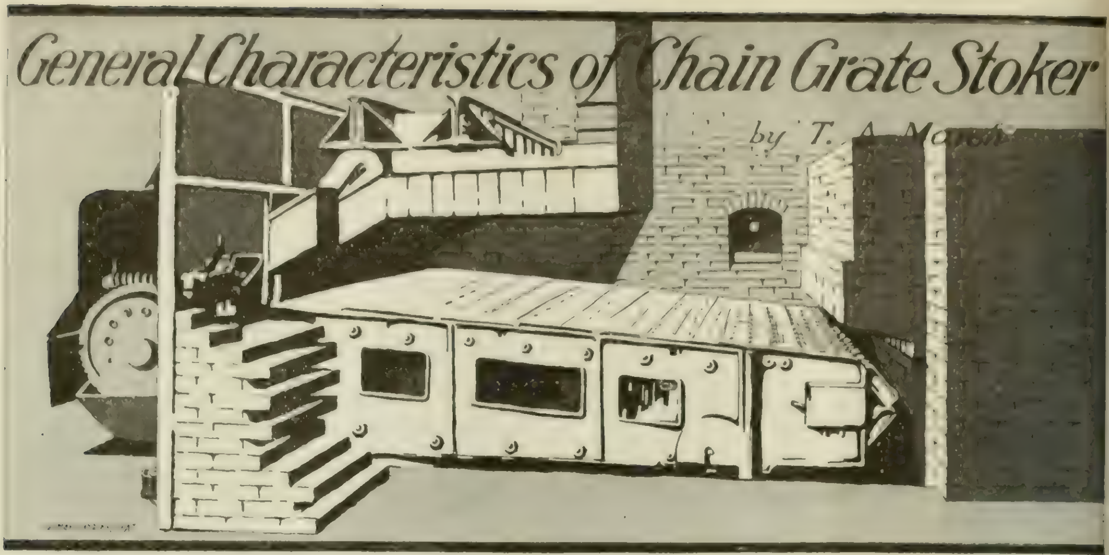
In operation the air from the windbox passes to the channels back of the brick and escapes through the openings in the blocks, absorbing some of the heat of the bricks, the idea being that as the bricks are kept comparatively cool, adhering clinkers will be prevented.



APPLICATION AND DETAILS OF THE DRAKE FURNACE BLOCKS

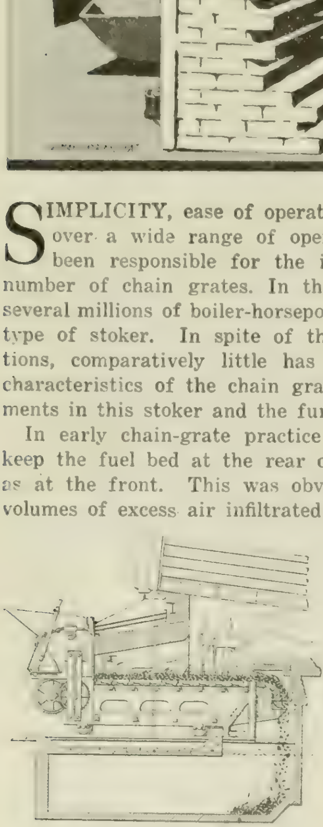
General Characteristics of Chain Grate Stoker

by T. A. Marsh*

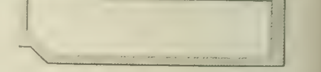


SIMPLICITY, ease of operation and high efficiency over a wide range of operating conditions have been responsible for the installation of a large number of chain grates. In the United States alone several millions of boiler-horsepower are served by this type of stoker. In spite of the number of installations, comparatively little has been written on the characteristics of the chain grate and recent developments in this stoker and the furnace serving it.

In early chain-grate practice it was impossible to keep the fuel bed at the rear of the stoker as dense as at the front. This was obviously wrong as large volumes of excess air infiltrated through the thin fuel bed at the rear. The introduction of the waterback improved operating conditions. When properly set it permits compression of the fuel bed, and makes it possible to obtain the desired density at the rear of the grate. To a certain extent this is under the control of the operator. Excess air around the rear of the grate is eliminated and special plates shut it off at the sides, so that 13 to 16 per cent. of CO_2 is not unusual. Water-backs also help in retaining the coke and in reducing the combustible in the refuse to a lower percentage than was possible with the early installations that did not have this equipment.

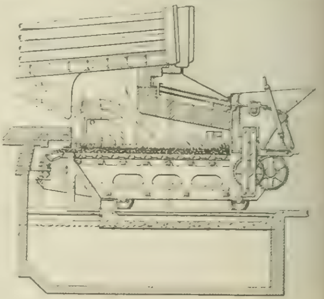


In some quarters the opinion has prevailed that boiler operation appreciably below normal rating means low efficiency. The basis for this opinion probably is due to experience in hand-fired practice, where it is difficult to carry a thin, light fire and keep it free from holes and excess air. It perhaps is not generally appreciated that chain grates do carry light loads efficiently. In fact, with furnaces of limited design the economy is better than can be obtained from these same limited furnaces at the higher rates of combustion. Ratings below normal have not claimed the interest of combustion engineers, owing to the desire to obtain high overloads, so that test data for the most part relate to operation above rating. If a stoker cannot be operated efficiently at low ratings, it is a serious drawback where light loads occur for extended periods. To show what may be accomplished in this direction the accompanying table is presented. It gives results from Green chain grates under several types of boilers. It is not sufficient to remark that the chain grate will develop high efficiencies at low ratings. The cause is the interesting item. For the burning of high-volatile coals most furnaces have been designed with insufficient volume for the combustion of the gases. Usually, the furnace has from one-fifth to one-tenth of the volume needed. The average chain-grate installation in the United States has been designed



CHAIN-GRATE EFFICIENCIES AT LOW RATING

Type of Boiler	Coal Burned per Sq.Ft. per Hr., Lb.	Furnace Draft, In. of Water	Per Cent. Rating	Combined Efficiency
Edge Moor.....	16.88	0.16	113	81 9
Stirling	16 50	0 09	107	78 3
Stirling.........	14 40	0 10	91	77 4
B & W	7 90	0 03	57	78 4
Geary.......	20.00	0 18	105	77 5



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*Chief Engineer of Green Engineering Co.

and provided with draft to burn 25 to 40 lb. of coal per square foot of grate area per hour, with a furnace volume capable of obtaining complete combustion from only about 10 lb. of coal.

In Europe, where there are a great many chain-grate installations, the practice follows the idea of large grate area and low combustion rates. Normal loads are carried with combustion rates of from 10 to 15 lb. per square foot of grate area per hour, while peaks are carried with combustion rates of two to three times this amount. Naturally, the efficiency of combustion, or true furnace efficiency, is superior to that obtained over a higher range of combustion rates, and since efficient boilers and economizers have been developed also in Europe, there is little wonder that over-all efficiencies are high. Low combustion rates permit complete combustion of the gases in the furnace without the usual 5 to 15 per cent. hydrocarbon, or so-called unaccounted for, loss. By the same reasoning it is evident that if furnaces are designed with volumes great enough to permit the complete burning of the gases at high ratings, high efficiencies will also be obtained at high ratings. With furnaces having a combustion space of 10 to 24 cu.ft. per square foot of grate area, chain grates are developing combined efficiencies of from 70 to 80 per cent., which decrease only as the efficiency of heat absorption of the boiler decreases.

In the earlier chain-grate installations it was difficult to obtain as high as 12 per cent. CO_2 on account of the thin fuel bed at the rear, and the efficiency was actually higher if lower CO_2 of about 10 per cent. was carried. This is direct evidence of insufficient furnace volume.

With modern chain-grate furnaces, 14 per cent. CO_2 may be carried during regular operating periods and the maximum furnace efficiency corresponds with the maximum CO_2 up to the point where CO is developed. Modern practice has, therefore, increased the combined efficiency of the unit approximately 10 per cent. on the average, largely by an agency separate from the stoker itself, the furnace. True, the stoker must be constructed with air seals, waterback and ledge plates to prevent excess air, but this also is part of modern chain-grate design and construction.

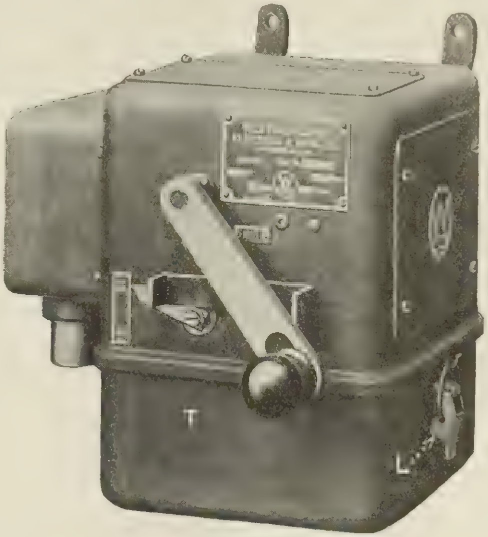
Other well-known characteristics of chain grates are continuous ash discharge, minimum clinker, ability to burn low-grade coals and lignites, grate surface always clean, low labor requirements and power for auxiliaries less than ½ of 1 per cent. of that developed. The chain grate covers an important field in combustion service, and it is certain that by a study of the stoker, the furnace and the heat absorber separately, there is opportunity for improvement in operating efficiencies.

Quick-Make Starting Switch

One of the new equipments brought out during the last year is a quick-make and quick-break switch (see illustration), designed for use where three-phase 220-, 440- and 550-volt squirrel-cage motors of capacities from 2.5 to 25 hp. are started with full-line voltage. In addition to being a motor-starting switch, it can also be used to control feeder circuits up to 100-ampere capacity. It may be supplied in any of the following combinations for either hand or shipper-rod operations: (a) Nonautomatic switch; (b) switch with low-voltage protection; (c) switch with inverse time-element overload protection; and (d) full automatic switch with low-voltage and inverse time-element overload protection.

On account of the positive action of the contacts this switch is especially suitable for shipper-rod operation. It is impossible for the operator to retard the motion of the contacts after they have started to close—there can be no "teasing" of the contacts. Contacts are opened and closed in oil, thus effectually suppressing arcing.

Drawn-steel construction is used, giving maximum strength with light weight. The oil tank *T* is supported by snap-ring latches *L*. Removal of the tank clearly exposes the contacts and makes them easily accessible. When necessary to replace contacts, each may be removed by taking out a single screw.



QUICK-MAKE SWITCH COMPLETE

The contacts and contact supports of this switch, which is built by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn., are of the same construction as used on this company's type A auto-starters and magnetic contactors. This minimizes the number of spare parts that should be carried.

The low-voltage protection not only opens the contacts on failure of power, but makes it impossible to close them again until return of voltage. A safety stop may be provided by connecting one or more push-buttons in series with the low-voltage coil.

The overload relay is the same as that used on this company's type A auto-starters. It has the inverse time-element feature and is equipped with a regulating device, adjustment of which controls the degree and duration of the overload possible on a motor or feeder circuit. This adjustment can be made without opening the switch cover.

An additional safety feature is a hand reset which makes it necessary to set the mechanism before the switch contacts can be closed. Thus protection is afforded workmen and valuable machinery which might be injured by accidental starting of the motor.

The Electrical Study Course—Two-Wire and Three-Wire Systems

Presents a general outline of the factors to be considered in problems pertaining to wiring and proceeds to show the desirability of using high voltages and also what the disadvantages are. It is then shown how both high and low voltages may be secured by the use of a three-wire system.

TO CONVEY electrical energy from the place at which it is generated to that at which it is to be applied, we make use of conductors known variously as mains, lines, systems of wiring, etc. Several considerations enter into the choice of the system to be employed and into the sizes of the conductors comprising it. In direct-current work there are essentially only two systems from which to choose: namely, the two-wire and the three-wire. It is the purpose of the present lesson to discuss their respective merits and drawbacks, but before proceeding to do so, it will be well to give some consideration to the other part of the subject: namely, the factors governing the size of conductor required for a given service. It will be found that the three-wire system is the direct outcome of the deductions to be made from such a study.

TABLE OF WIRE SIZES AND CARRYING CAPACITIES AS APPROVED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS

B & S Gage Number	Diameter of Wire In.	Area in Circ.-Mil.	Rubber Insulation Amperes	Other Insulations Amperes
18	0.0403	1,624	3	5
16	0.0508	2,583	6	10
14	0.0641	4,107	15	20
12	0.0808	6,530	20	25
10	0.1019	10,380	25	30
8	0.1285	16,510	35	50
6	0.1620	26,250	50	70
5	0.1819	33,100	55	80
4	0.2043	41,740	70	90
3	0.2294	52,630	80	100
2	0.2576	66,370	90	125
1	0.2893	83,690	100	150
0	0.3250	105,500	125	200
00	0.3648	133,100	150	225
000	0.4096	167,800	175	275
		200,000	200	300
0000	0.4600	211,600	225	325
		300,000	275	400
		400,000	325	500
		500,000	400	600
		600,000	450	680
		700,000	500	760
		800,000	550	840
		900,000	600	920
	......	1,000,000	650	1000

The problems involved in the installation of any wiring may be divided into two general classes, one of which is concerned with its safety and the other with its efficiency. Under the former head are included, first, protection from injury to persons and to the wiring and its surroundings, due to accidental contact, grounds, short-circuits, and the like; and secondly, provision against the overheating of the conductors due to the current carried by them. The first object is accomplished by using wire and devices approved by competent authorities, such as boards of fire underwriters, and by installing them in accordance with the recommendations of such bodies. The heating of the conductor for a given current is dependent upon its size, and it is therefore necessary to install the correct size of wire in addition to doing it in an approved manner. Experience has indicated what are the maximum values of currents which wires of various sizes and kinds of insulation may carry without attaining unsafe temperatures. These data, as approved by the National Board of Fire Underwriters, for copper wire, are given in the accompanying table.

The efficiency of the installation depends on the losses in it, and partly on its voltage regulation. As we know, the loss in any conductor carrying current is the product of its resistance and the square of the current. Thus, if W represent the loss in watts, I the current in amperes, and R the resistance in ohms, we have $W = I^2R$. It would therefore appear that we need merely make R very small in order to reduce W to a negligible quantity, and hence make the efficiency of transmission very high. However, the size that it is practicable to use is limited by the cost of the wire and the expense of installing it. The larger the wire the more costly it and the wiring appliances would be, and the more labor it would require to install it. When the cost of electrical energy is high, it is economical to spend a relatively large sum of money for wiring, in order to keep down the losses. On the other hand, if the energy is comparatively cheap, it is less expensive to waste a considerable percentage of it than to tie up a big sum of money in large-sized conductors.

The ordinary problem of wiring, however, does not call for any extended analysis. The controlling factor is usually the drop in voltage in the line, particularly when the load consists of lamps, in which case the size of wire used must be such that there is no objectionable change in candlepower with change in load. For example, if a load consisted of three hundred 50-watt 120-volt lamps, the full-load current would be $\frac{300 \times 50}{120} = 125$ amperes. If the maximum allowable change in voltage is determined upon as being 2 volts, we would have that the resistance of the line must be $\frac{2}{125} = 0.016$ ohm. The size of wire to be used then depends upon its length. The longer it is the larger it must be in order to keep the total resistance down to the value determined.

To recapitulate, wiring problems involve the following features:

- (1) Safety
  - (A) Method of installing
    - (a) Approved wire
    - (b) Approved devices
    - (c) Approved workmanship
  - (B) Heating..........(d) Correct size of wire
- (2) Efficiency
  - (C) Loss in line..........(e) Size of wire
  - (D) Voltage drop in line.. (f) Size of wire

Thus it is seen that the size of wire affects the heating, line loss, and line drop, and therefore any one of these three items may be the controlling factor in the choice of the size to be used for a given current. From any of the three standpoints a larger current calls for a larger wire. It is therefore best to restrict the current to as small a value as possible.

Now the current is dependent upon two elements—the load to be served and the voltage of the service. That is, $W = EI$, where W is the load in watts, E the voltage, and I the current required at that voltage. Consequently, for a given load the current may be reduced by increasing the voltage, and the question becomes one of how high to make the voltage. Various factors must be taken into account in making a decision, among which are, safety to operatives, increasingly effective (and therefore increasingly expensive) insulation at higher voltages, possibility of obtaining apparatus to operate at the voltage chosen, and others of like kind. Since the two most extensive uses of electricity are for power and for lighting, the decision must be based upon the requirements of such services. Power is of course furnished through the medium of motors, and such machines can be constructed to operate satisfactorily at considerable voltages; the limit, in industrial direct-current work, is usually established between 500 and 600 volts, although in electric-railway work voltages up to 5000 have been used. Lamps, on the other hand, give the most satisfactory results when designed to operate in the neighborhood of 120 volts. When motors and lamps are to be supplied with power from the same service, it is almost compulsory to make the best lamp voltage the controlling element. No matter how desirable it might be to operate the motor load at 500 volts, it would be out of the question to use lamps for such a voltage without operating them in series groups, which, to say the least, is very unsatisfactory. If the motor voltage were reduced to 250 volts, it would be possible to use lamps on the service, but not advisable. The most satisfactory method is to use lamps which operate at from 110 to 125 volts. It has, however, the disadvantage of requiring a line wire designed to carry twice as much current as at the higher voltage, which even for the lighting load is a serious handicap, but which for large power service makes it almost prohibitive.

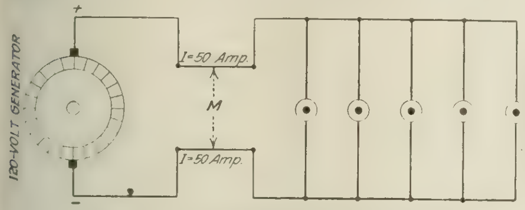


FIG. 1. TWO-WIRE 120-VOLT CIRCUIT

To meet these conflicting conditions a method of distribution known as the three-wire system was evolved, which differs from the ordinary circuit, requiring two wires, in the fact that it makes use of three wires as its name implies. The principle upon which it was developed may be explained as follows:

Assume that it is required to use one hundred 60-watt 120-volt lamps to furnish a certain amount of illumination. The total amount of power to be supplied would be $W = 100 \times 60 = 6000$ watts. If the load were supplied from a 120-volt two-wire system, as illustrated in Fig. 1, the current required would be $I = \frac{W}{E} = \frac{6000}{120} = 50$ amperes. If the voltage drop in the line M were to be restricted to 3 volts, its resistance would have to be $R = \frac{E}{I} = \frac{3}{50} = 0.06$ ohm, and the power lost in it would be $I^2R = (50)^2 \times 0.06 = 150$ watts. Suppose, now, that the lamps were arranged as shown in Fig. 2; that is, that they were divided into fifty groups of two lamps in series. In that case it would be necessary to impress a voltage of 240 volts across the mains in order to make the lamps burn at their proper brilliancy. The total load would be the same, and we should therefore have $I = \frac{W}{E} = \frac{6000}{240} = 25$ amperes, or half the current required at 120 volts. The difference arises from the fact that at 120 volts we have 100 paths through the lamps, each taking 60 watts, or $\frac{60}{120} = 0.5$ ampere; whereas at 240 volts we have only 50 paths, each taking that current. If we were to allow the same line loss in the latter case as in the former, we should have $(25)^2 \times R = 150$ watts, from which we find $R = \frac{150}{(25)^2} = 0.24$ ohm, a value four times as great as required before. The voltage drop in the line would be $E = IR = 25 \times 0.24 = 6$ volts, twice the value at 120 volts; but since the lamps are arranged two in series, a drop of 6 volts across the two is equivalent to a drop of 3 volts across each, the same as on the 120-volt circuit. Consequently, the resistance of the line could be increased fourfold without changing either the loss in it or the voltage drop to the lamps. The cross-section of the wire could therefore be made one-quarter of what it was, which means that only one-quarter of the weight of copper would be required, with a corresponding reduction in the cost of the installation. It may be pointed out here that a reduction to one-quarter of the cross-section is equivalent to halving the diameter. Thus, the area of a rod 0.4 in. in diameter would be $\pi \times (\text{radius})^2 = 3.14 \times \left(\frac{0.4}{2}\right)^2 = 0.1256$ sq.in., whereas that of a rod of half the diameter, namely, 0.2 in., would be $3.14 \times \left(\frac{0.2}{2}\right)^2 = 0.0314$ sq.in., or one-fourth of the other. That is, the area of a circle is proportional to the square of its diameter.

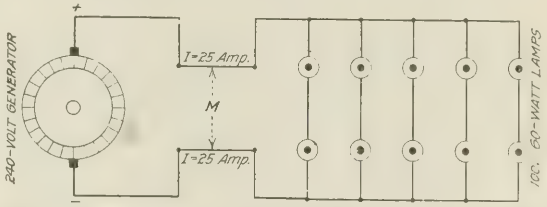


FIG. 2. TWO-WIRE 240-VOLT CIRCUIT LAMPS GROUPED TWO IN SERIES

An arrangement of lamps such as that indicated in Fig. 2 could be operated satisfactorily if they were always required in pairs, but otherwise the scheme would not be practicable, since by turning out one lamp the other would also be extinguished. There are additional drawbacks to the series system in that the lamps must be identical, or they will not burn at the same brilliancy, a short-circuit in one results in double normal voltage being impressed upon the other, causing it to burn out, and both lamps are extinguished if either one of them fails.

These undesirable features may be eliminated by the use of a method such as that represented in Fig. 3, which is the typical diagram of a three-wire system. Instead of using a single source of 240 volts, two sources of 120 volts each are connected in series and a connection is made at the junction *a*, and run as a third main wire to the load. It is commonly referred to as the neutral wire or merely as the neutral of the system, and the other two lines are known as the outside wires. Thus, in Fig. 3, *N* is the neutral and *A* and *B* are the outside wires. It will be noticed that a voltage of 240 volts exists between the outside wires *A* and *B*, but that that between either outside and the neutral is only 120 volts. Also that the neutral is negative in reference to one outside wire and positive in reference to the other. In a future lesson it will be shown how such a system overcomes the objectionable features of the straight series arrangement and yet retains the advantage of effecting a material saving in copper as compared with that required for the wiring in a two-wire 120-volt system.

The problem of the preceding lesson concerned three compound generators of 50 kw., 120 kw. and 200 kw. capacity respectively. The resistance of the series field of the 50-kw. machine was stated to be 0.01 ohm. It was required to determine what the resistances of the series fields of the other two machines would have to be if it was intended to operate the three generators in parallel. For any load on the generators the 100-kw. machine should deliver twice as much current as the 50-kw. one, and the 200-kw. machine four times as much, consequently the currents through their series fields should be of those values. Since all the series fields are connected across the same voltage—namely, that between the equalizer and the busbar at the other side of the fields—the resistance of the series field of the 100-kw. generator must be half that of the 50-kw. one if the current through it is to be twice as great as that through the latter. Similarly, the resistance of the 200-kw. generator would have to be one-quarter that of the smaller machine in order that its current should be four times that of the other. We therefore have that the series-field resistance of the 100-kw. generator should be $\frac{1}{2} \times 0.01 = 0.005$ ohm, and that of the 200-kw. one should be $\frac{1}{4} \times 0.01 = 0.0025$ ohm.

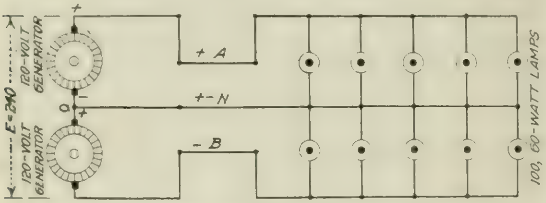


FIG. 3. THREE-WIRE 120- TO 240-VOLT CIRCUIT

A line of rubber-covered wire is to be run 150 ft. to supply current to fifty 100-watt 125-volt lamps and twenty ½-hp. 125-volt motors. If the size of the wire used is that called for by the Underwriters' rules, what would be the voltage drop in the line at full load? Also, what would the loss in it be?

A Discussion of Belt Tighteners

By Charles Crane

A belt tightener, to function properly, should be so designed that it will maintain nearly the same tension on the slack side of the belt under all loads. Others should really be called adjustable idlers, for if the pulley remains in a fixed position and a heavier load comes on, the pulling side of the belt will stretch and the slack side will become more slack, which will allow it to drop away from the tightener pulley. This will relieve the tension on the belt just at the time when it should have more tension, and it will slip and have a tendency to run off. A crown-faced pulley has nothing to do with the belt running to one side, for if a tightener pulley leads a belt to one side at all, it will run in nearly the same position under all loads.

Any idler pulley may be made to lead a belt a little to either side by simply throwing the idler out of line with the center line of the belt. Imagine a belt standing still and a pulley being rolled along on it. If it is in line with the belt it will stay on, but if it be turned a little to one side it will run off. Suppose the belt moves and the pulley is held in one place but turned a little to one side, as before. It is evident that the pulley cannot run to one side, therefore it will exert a pull on the belt in the opposite direction, which will tend to run it to one side until the force exerted is counteracted by the pull of the crowned faces of the drive and driven pulleys tending to hold the belt on, in which position it will remain.

The type of tightener is unimportant so long as it is allowed to play freely and maintain an even tension on the belt; but a swing tightener—that is, a rigidly built frame lying parallel to the belt and hinged at one end to a support, the other end carrying the pulley—is preferable as it is of simple construction, plays more freely and is easier of adjustment for leading the belt.

It seems to be the universal practice to set the tightener pulley as close as possible to the driven pulley. The reason generally given, outside of it being customary, is that it gives the belt a greater arc of contact on the small pulley. With the tightener placed close to the driven pulley, an increase of load will stretch the pulling side of the belt and the extra slack will run off at the driver first. This slack having nearly the full length of the slack side of the belt, before it reaches the tightener the belt will start flapping and the tightener will play up and down. When the tightener rises quickly, it may be carried too far by its momentum, with a resultant release of the tension on the belt, allowing it to slip. With a belt running at high speed excessive flapping will often entrap a little air between the belt and the pulley face, which will greatly reduce the contact area. When the tightener is close to the driver, it will take care of the slack the instant it runs off the driver, and the belt and tightener will run much more smoothly, which will more than offset the advantage of the extra arc of contact obtained by the former method.

The great demand for radium, in connection with its scarcity, makes it perhaps the most valuable mineral. Gold is worth $20 an ounce, but an ounce of radium is estimated to be worth more than three million dollars.

EDITORIALS

Limits in Turbine Capacity

SOMEONE is trying to lay the steam turbine on the bed of Procrustes. There is in the air the question of limiting its capacity at 30,000 kilowatts. Just why the tenuous discussion should select this capacity as the limit is difficult to conjecture. It sounds like judgment made in the face of overwhelming facts; it is akin to denying the existence of Niagara Falls.

In the first place a turbo-generator must be reliable regardless of capacity. With reliability assured and cost considerations cared for, the chief reason for selecting units of various sizes or various units of the same size for a plant is to enable carrying the load throughout the day at the most economical water rate. Of course there should be units enough, or provision made, to continue service and permit of cleaning and repairing—there must be spare capacity.

Since the introduction of the turbine the trend has been upward. As unit capacity has been increased, the water rate has decreased, and with it the cost, not only of the unit itself, but of the whole station, has fallen. With the growth of large power systems supplied by a few huge stations operating in parallel, costs would be seriously affected if for the system units of 30,000 kilowatts or under were selected. True, such limit might be best for some stations or some systems; but it is idle to ask the camel to take no greater stride than the burro. Standardization is desirable until it is made abortive and retrogressive. Fixing 30,000 kilowatts as a limit for steam turbines seems to us to be of this class. The factors that will fix ultimate capacity are the physical limits, shop practice, and shipping restrictions. Capacities have now reached 70,000 kilowatts in one unit, the compound machine in the Seventy-Fourth Street Station of the Interborough Rapid Transit Company. If the load conditions warranted, no doubt the purchasers would have called for a 100,000-kilowatt machine.

Brighten Up the Boys' Home-Coming

IT HAS been said that electricity won the war. This statement no doubt can be challenged. However, electricity was one of the most potent factors in carrying on the world struggle to a successful termination for us and our Allies. There is scarcely anything that entered into the war machine in which electricity did not perform an important function. From the production of the raw materials and the conversion of them into munitions, and the utilization of these munitions at the front, we find electricity playing a master rôle. Even the plans of the master strategist would be of little use if it were not for the elaborate systems of communication made possible by the use of electricity.

The big job is done and the boys are returning to us victorious. They have done the work they were sent to do, done it heroically, in a much shorter time than expected. Many of them have paid the supreme sacrifice and now rest in the sacred soil of France. Many of those returning have been wounded and have suffered long days and weeks in the hospitals in France, and realize that they return to civil life greatly handicapped to compete with their more fortunate brothers.

When they left us gloom was cast over this country, curtailment of light and silence was the order of the day. Transport after transport, laden with our boys, silently left our shores for "Over There" without any send-off or outward demonstration of any kind. They made the trip on darkened vessels through submarine-infested waters and arrived in the darkened cities of war-saddened Europe. Now that they are returning and all restrictions are off, let us make this home-coming in keeping with the feelings of a great and victorious people, proud of the good work the boys have done. What better agent can we employ to do this than electricity?

This brighter home-coming is something we owe to the boys; it is a national duty and something that every citizen can take part in, either by letting the lights shine in his home, office, shop or plant or by the construction of large electric signs of welcome. Central stations, manufacturers, contractors and dealers, who have not already done so, can get behind this great movement by getting in touch with the International Association of Rotary Clubs, chambers of commerce and committees appointed by civic authorities and other trade associations.

What About the Pumps?

IT HAS been pointed out many times that the power-plant pump should receive the same attention that is given to steam engines and other power-plant apparatus, but it is well known that the pump in most instances is neglected and left to run itself, perhaps because it is simply constructed and seems to possess a faculty for getting on without much help from the attendant.

This neglect may be because pumps are so frequently placed in out-of-the-way places instead of where they are readily accessible. Be that as it may, it is evident that although a pump can withstand a large amount of neglect, there comes a time when difficulties will be encountered, and the blame rests with the man who is supposed to care for the pump.

First of all, a pump should be placed in a convenient, clean and well-lighted location, if possible. It will then be likely to receive some attention. Naturally, a suitable foundation will be necessary, otherwise there is danger of a leaky suction pipe, groaning of pistons and general vibrating troubles.

It will be conceded that the pump, as is true of any other machine, should be kept clean, both inside and outside. This means frequent internal inspection because the fact that the pump is operating satisfactorily today is no assurance that it will do so next week. To be reliable the machine must be kept in good repair.

Examinations are necessary in order to detect what parts are wearing, how fast they wear and to determine when to renew parts before they give out entirely and perhaps cause a shutdown. If a suitable strainer is attached to the suction pipe, there will be less valve trouble in the water end, and interior inspections may be reduced to, say, about four times a year.

Pump trouble generally occurs in one of three places—suction pipe, water end or steam end—but as certain difficulties have certain symptoms, locating the trouble is less difficult to the man who understands the machine. However, if it is necessary to run the pump faster this week than last, it indicates that the plunger needs looking after and that leakage is occurring past the packing; or it may be that a valve is hung up by some obstacle. A jerking action and pounding of the water piston indicate clogging of the suction pipe, and lack of air in the air chamber is usually evidenced by a dull thud at the end of the stroke. Thus it is seen that each trouble tells its own story by the action of the pump. A careful study of the machine will usually direct one to the cause of the trouble.

One of the greatest neglects of a steam pump is due to lack of lubrication, as on account of its location the lubrication is in many instances intermittent. The trouble is that the lubricator is allowed to run empty and remain so because someone thinks there is sufficient oil in it for hours to come. No engineer would think of lubricating the cylinder of a steam engine on a hit-and-miss plan, but that it just what is done with the majority of steam pumps in the average steam plant.

It is needless to say that a well-designed and constructed steam pump, when given proper care, will give reliable service and will not be a tax on the time of an engineer any more than any other piece of well-made machinery found in the plant.

Increased Rates for Electric Service

THE recent decision of the Railroad Commission of the State of California authorizing the California Edison Company to increase its rates for electric service is another instance showing that public utilities may expect a square deal from the public if the former render the latter an adequate service. It is worthy of note that at the hearings all parties interested were present, but not a single objection was raised to the increase in rates. President Edgerton of the commission wrote in his opinion: "I am convinced that we will be acting with entire fairness to the applicant as well as to consumers if we fix rates so as to put the applicant in approximately as good condition as it was before these abnormal increases in cost."

The attitude of the California Edison Company during the crisis has been a commendable one, in that it has made an honest effort to maintain its high standard of service without increasing its rates and only making application when an increase was absolutely necessary. This attitude, judging from the results of the decision, appears to have been one which might profitably be followed by utilities in general.

Engineers' license laws are founded on considerations of public safety, but to bring out the skill and intelligence of applicants for licenses, the inquiries have been largely directed to the applicant's knowledge of design and technicalities of engine-room practice. Now that fuel conservation is so commonly recognized to be an important question of national preservation, examiners will do well to switch some of their attention to the economics of boiler-room practice.

Exhaust steam, when available, can frequently be substituted for live steam in heating coils, etc., with but slight changes in the equipment. There is a general belief, however, that the difference in the total heat between exhaust steam at atmospheric pressure and steam at, say, one hundred pounds pressure is considerable. A glance at the steam table will show that the difference is less than forty British thermal units.

It is an engineering fact that a column of water one foot in height exerts a pressure of slightly under one-half pound per square inch, and, conversely, the pressure of half a pound per square inch will support a pound of water one foot in height. If some of the articles recently published regarding water flooding radiators are criterions, it would seem that some heating engineers have overlooked this truth.

The war has been responsible for the introduction of many new words, and a leading British paper in defining one of them said, "These men have been labeled 'pivotal,' which means that their work is a necessary preliminary to the employment of others." Practical men can realize that for many purposes the word "pivotal" is more exact and specific than "indispensable."

Although there is danger of spontaneous combustion with stored bituminous coal, it is safe to assume that after the first summer it will not catch fire unless it is disturbed, in which case the coal will heat the same as when first piled, and will catch fire as readily. Coal having a tendency to heat unduly should be let alone after storing, otherwise there is likely to be trouble.

Every engineer should have a simple boiler-room log for keeping a record of the fuel and water used, the evaporation of water in pounds per pound of coal burned and the weight of ashes obtained. Although such a record is easily kept, there are thousands of plants in which nothing is known as to the performance. Is it not about time to wake up?

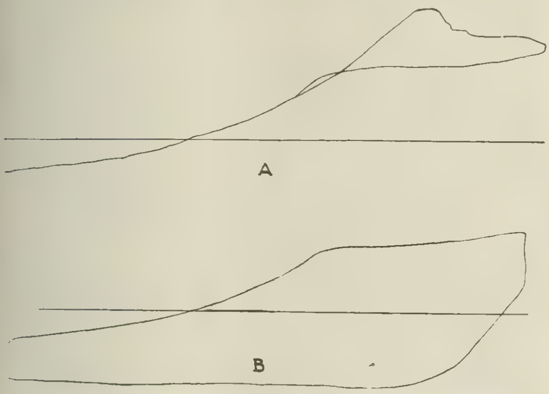
Passing laws and signing ordinances will not supply the human race with food and clothing. The man who sticks day after day to some form of productive labor is of infinitely more account than the chap who spends all his time trying to convince his fellows that the world can get along without working.

The loss of heat from the surfaces of steam pipes and cylinders is commonly termed radiation; but a part of the heat is carried off by convection, or the sweeping of air currents over the heated surfaces.

CORRESPONDENCE

Misadjustment of Exhaust Valve

The indicator diagrams shown are from the low-pressure cylinder of a 9 x 16 x 36-in. compound Corliss engine. The engine had been taken apart, and I had given instructions as to the correct manner of replacing the valves. On starting up, however, there was a bad knock in the low-pressure cylinder. The indicator justified the suspicion as to the cause of the trouble by producing diagram *A*. The crank-end exhaust valve was improperly placed and connected, so that it did not open at all. The steam was compressed to a pressure above that of the receiver, lifting the admission valve from its seat, producing severe "slamming" on its return. Diagram *B* was produced when the valve was put in right.



FREAK DIAGRAM WHEN VALVE WAS IN WRONG

Victor R. Gage.

Ithaca, N. Y.

Lubricating Cylinders and Bearings

I believe it is a rare case indeed where a bearing heats because it is getting too much oil, as has been suggested. Bearings on high-speed engines, especially eccentrics, cause trouble because dirt or pieces of waste get into the oil holes which lead to the oil ways. Large eccentrics as well as crank boxes and main bearings often get hot because the oil ways have been worn down. It is necessary to provide oil grooves and also to scrape down the approach or "leading in" side.

A generous supply of oil (flooding) will cushion the pound and make it unnecessary to key up the bearings frequently. In one instance where they had been in the habit of keying up every week, I was able to reduce this to six or eight weeks. Part of this improvement was due to an improvement in the valve setting.

The most difficult cylinders to lubricate are those that get superheated steam and saturated steam alternately. I made good on one job on which others had failed because I found out that the foregoing conditions prevailed and took steps to improve the situation and to find the proper cylinder oil for the peculiar condition. With saturated steam the oil should be compounded with tallow oil, and it is advisable also to compound, slightly, oils for superheated steam because the steam is always wet when starting up and a spray of water may sometimes come over from the line even with superheated steam.

W. Waldo.

Foster, Ohio.

Boiler Blowoff Valves

I have been following the discussion on blowoff valves, expecting someone of more experience to bring out what looks to me to be the vital point; namely, that one of the two valves, or a valve and cock, is for emergency use. In this state (Ohio) the law calls for two valves, or a valve and plug-cock, on boilers that carry in excess of 135 lb. steam pressure. The old through-plug style of cocks is limited to 25 lb. pressure. Some of the illustrations showing blowoff lines are fine, with plenty of room, but they cannot be so arranged with boilers set with the mud drum not more than six inches above the floor.

A few years ago I was working in a plant that had two valves on the blowoff line, and the boilers were blown down by opening the valve next to the boiler last and closing it first. This seemed the ideal way, even when the first valve began to leak, but in a few days the second one also began to leak, and the chief told me to put on a new one. The line was in a trench, and while putting on that valve with hot water all around me, I was convinced that the order of blowing down was wrong. I concluded that two valves or a valve and cock were on a blowoff line for emergency use. A cock was put next to the boiler and left open, except in emergency, therefore the wear was within the plug, and so did not affect its tightness. If we had put a valve next to the boiler and left it open, the seat would have been cut out in a short time, and if we shut and opened it every time, it would probably leak and be "no good" in case it was needed badly. Our firemen blow the boilers down once every eight hours and our blowoff line shows "drop tight" after two years' service. I will repeat what a chief, whom I was once repairman for, told me: "Keep an emergency appliance for an emergency and keep it so it will function when the emergency comes."

Barch Smith.

Newark, Ohio.

Speaking of boiler blowoff valves, have readers noticed that the majority of manufacturers mark their valves to be placed so that the stem stuffing-box is continually subject to boiler pressure? Most of us put all valves on the other way, and I prefer to so place a blowoff valve. I use a flanged valve next to the boiler and an asbestos packed stop-cock outside and open the stop-cock first, then the valve, because the valve is more easily handled. With this arrangement the stop-cock and packing on the valve stem may both give out and still leave the valve good. If the valve leaks it will usually leak into the line instead of out through the stuffing-box, which is just as wasteful but not so dangerous as letting it go outside.

Our valves do leak sometimes and have to be watched and taken care of, but who ever saw a valve that did not need attention? Besides, if they did not need attention, what would we do to earn our money?

Philadelphia, Penn. T. A. MARSHALL.

Making Diesel Operators from Steam Engineers

The letter by Mr. Cooke on page 27 in the issue of Jan. 7, "Making Diesel Operators from Steam Engineers," will, I feel, strike a sympathetic chord in the breasts of genuine steam engineers. Some years ago an electric plant with which I was conversant had a mixed power plant. Part of it was steam-driven and part was Diesel-engined, and all units supplied current to a common switchboard.

As the current generated was alternating, it was essential that the units be brought in step and synchronized properly. The oil sets consisted of two three-cylinder Diesel-engine units with an alternator between, and there were several of these sets. Each part of the power house—that is, the steam section and the oil section—had its own chief engineer, which is the worst possible combination. Trouble developed with the governor of one of the Diesel sets, and the chief, who I am told was an excellent machinist, was unable to remedy the trouble; so, after two or three days of agony, the general manager got the steam chief on the job.

"Have you put the indicator on to see if you can locate the trouble?" he asked the oil chief.

"I know where the trouble is," he was informed.

"Then why don't you remedy it?" the general manager asked.

"It's in the governor, but I can't seem to locate it," he replied.

Well, to summarize, the steam engineer used his own steam-engine indicator, which had a special oil-engine bushing for the cylinder, and found that the middle cylinder on one engine was not doing any work worth mentioning because no oil was being injected into it. He found, further, that a pipe scale or something of like nature had closed the extremely small oil-valve opening. After this was cleared, the governor functioned properly.

This little incident does not prove that oil engineers are not "onto their jobs," to use a slang expression, but that this oil engineer, who had come well recommended, was not as thorough a power-house operator as the steam man. In connection with the Diesel plant there was a very nice compressor plant consisting of a four-stage compressor driven by a cross-compound Corliss engine, a self-contained outfit, but who do you suppose had to look after this outfit? Not the Diesel chief, but the steam chief. I believe that there are Diesel experts and also steam-engine experts, but many are at best only throttle openers and closers; nevertheless the steam engineer that knows a power plant from start to finish need not worry at the micrometer adjustments or the "full-jeweled movement" of the Diesel.

New York City. C. W. PETERS.

Pump Valves Do Not Wear Well

From the letter by M. C. Larsen on page 30 in the issue of Jan. 7, it seems to me that his only trouble is poor material in the valves. Hard-rubber composition valves, made to resist the action of hot water, should not wear out and break in two weeks or even in two months. If there is acid or other chemicals in the water strong enough to destroy the valves in two weeks, it would also destroy the iron pipe work, therefore the fault must be in the valves.

In the plant where I am employed we have pumps working 24 hours a day handling water with an average temperature of 190 deg., and the hard-rubber valves last from one to two years, only requiring refacing a couple of times. Mr. Larsen should examine the valve seats and make sure they are level and that the springs on the stud bolts are not overstrong. I have used a metal-bound valve in the same class of work, which gave excellent results. JAMES E. NOBLE.

Portsmouth, Ont., Canada.

Methods of Banking Fires

Banking fires, as referred to in an editorial in the issue of Jan. 14, is a matter of great importance in saving time, money and labor. Pushing back the live coals to the bridge-wall and covering them over with green coal, especially soft coal, is a mistake. This kind of a bank will lie dead over night and probably Saturday afternoon and Sunday, allowing the boilers to cool down and reducing the pressure. On hauling those banked fires down again, probably one or two hours before starting time, it will take a good many shovelfuls of coal to get the pressure up to where it belongs. There are other things, however, that will waste coal. The blowoff and other valves leading from the boilers may be leaking, allowing the boilers to lose water during shutdown time; and to make up for this, one is likely to have to let a large quantity of cold water into the boilers before starting the fires. This water should be supplied beforehand through a heater when the plant is in operation.

Following is my method of banking fires. I do not push the live coals to the bridge-wall, but cover the fire all over with green coal (this is what we call banking fires flat) half an hour before shutting down, allowing the pressure in the boilers to drop 15 to 20 lb.; then I open the furnace doors wide and close the dampers and the ashpit doors. We close all valves but the stop valves. The pressure in the boilers varies only from five to ten pounds during the night. I claim that this method of banking fires saves the brick lining and also the boilers from sudden contraction and expansion in getting steam up before starting. Many firemen think that this method makes the fire hot to clean before starting, especially in summer. In the morning we open all dampers and push the fires back to the bridge-wall. We then close the furnace doors and let the front of the fire burn down to the ashes, which takes from five to seven minutes; then we clean the fire, which is cool at the front. I believe this is a good method as it has proved so in this plant. PATRICK MOLLOY.

New York City.

Setting Heavy Machine Bases

A comparison of two methods of procedure in lining and leveling machinery shows the advantage of parallel shims over wedges as follows: Three motors (5000, 4000 and 3250 hp.) were required in a 40-in. blooming mill. The first was set by using shims and wedges, and it required three men six days to set the base. It was first lined up, then leveled with wedges, then lined again which necessitated leveling again, etc. The trouble was that when the base was jacked over for line, sliding on the wedges raised one side and lowered the other and sledging the wedges to level up threw the base out of line.

In setting the other two the following method was used, requiring one day for each base. All thicknesses of shims from ⅝ in. to sheet tin were first secured. The base was raised with the crane and leveled on four piles of shims, no wedges being used. It was then lined up with hydraulic jacks and found to be still level. This made a saving on the two bases of ten days for three machinists, amounting to $198.

This method can be used on all machine bases, where they can be lifted with a crane or jacks.

Baltimore, Md. L. C. SCOTT.

Generator Wreck at St. Paul

It was with great interest that I read the description of the generator wreck at St. Paul on page 40 in the issue of Jan. 14 and the three probable causes of the wreck, but there is still another condition that might have produced the same results.

Since the six polepieces were of the bolted-on type, these bolts could become loose owing to the vibration, and when the short-circuit came on the generator it perhaps caused a polepiece to break away and take the other polepieces with it, wedging the rotating member until the shaft was twisted off.

Trenton, N. J. THOMAS F. MCELROY.

Protecting Safety Valves Against Tampering

A criminal act that might have caused a boiler explosion had it not been discovered by the night watchman or firemen makes me think that it is advisable to build a protection around safety valves, especially around the collieries, to avoid a similar occurrence.

One night two tramps entered a large coal-mine power plant and asked the firemen for permission to sleep there. As it was against the rules, they were refused, which made them mad. It appeared that they were would-be murderers and must have had some experience around boiler rooms, and as they went out they swore they would take revenge. Some time later in the night they returned, and finding the place unguarded, they tied an old carwheel on the lever of the safety valve and partly closed a 10-in. valve leading to the pump in the mine, expecting that the pumpman would call for more steam pressure. The pumpman thought that the steam was low, but did not bother calling up because the water in the sump was nearly all out.

Toward morning the watchman noticed that something had been done to the safety valve and called the attention of the firemen to it, and knowing that the carwheel was put there by some malicious person, they of course removed it. When the colliery started to work the following day, the large pump in the mine was stuck for steam and everybody was puzzled for a time until the trouble was located.

Plymouth, Penn. JOSEPH R. THOMAS.

A Dangerous Blowoff Connection

On reading the letter by W. W. Henry, on page 29 in the issue of Jan. 7, I wondered why engineers do not more often use the malleable flush bushing, if they use bushings at all. The ordinary cast-iron bushing is all right for low-pressure work, but should not be used in high-pressure steam work.

On one job where there was a 3-in. flange riveted to the boiler for a blowoff pipe and the contract called for 2½-in. blowoff piping, the contractor used a malleable flush bushing in the flange and 2½-in. pipe and fittings to finish up the work, and the boiler inspector passed it as satisfactory and safe. JAMES E. NOBLE.

Portsmouth, Ont., Canada.

I think W. W. Henry's criticism of the blowoff connection is well taken. However, he does not go far enough, for the 2½-in. connection to the boiler is not much stronger than the bushing, especially if there is any strain on the piping, as standard 2½-in. 8-thread pipe is so nearly cut away by the threads that it is the weakest of all piping we have. In this case as in nearly all others in which 2½-in. pipe is used, 2-in. would have answered just as well and made a better job.

This brings up a question I have had in my mind for a long time: Why do manufacturers insist on using odd-sized pipe connections where regular sizes would answer as well? A few years ago I ordered several large centrifugal pumps for irrigating. For one size their catalog specified 7-in. pipe connections. I asked them to furnish companion flanges for 8-in. pipe. I explained to them that 7-in. pipe could not be obtained anywhere short of the mills and that in 20 years' pipeline experience, I hadn't even seen a length of it; but it was necessary to send a man to their factory to get it done.

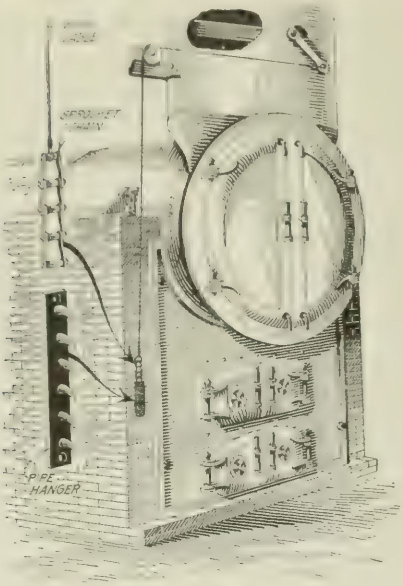
Another instance: A sawmill man came to a plant where I worked to borrow a 2½-in. nipple to repair a broken steam connection. Luckily, I had some oil wells just across the road from the plant, and I remembered having seen a piece of 2½-in. pipe on the lease—the only piece of 2½-in. pipe within miles—although there were hundreds of miles of other sizes. We had a pipe machine that cut all sizes from 1- to 6-in., so we cut him a nipple and sent him away rejoicing, as otherwise it would have meant a long trip to a machine shop for him. I could cite other similar instances in which pipe of odd size was used where the regular size would have answered just as well. **F. E. Myers.**

Charleston, W. Va.

Hand Damper Regulation

A convenient method of adjusting a hand regulated damper is to use a piece of six-coil pipe hanger. The boiler front is tapped for two 3/8-in. capscrews at a convenient point, and the hanger is screwed in place inverted, as shown in the illustration.

A wire rope is run from the damper to a small pulley and a few links of sprocket chain or a metal ring attached to the loose end of the rope. In some cases the damper shaft is not in the center and the damper will close itself when the rope is unhooked. Where the shaft is in the center of the damper, a weight on the end of the lever will close the damper when the cable is loosened. The various hooks permit of a wide range of control from closed to wide-open position.



A DAMPER CONTROL

Brantford, Ont., Canada. **T. Henwood.**

Carbon and Commutator Wear

Carbon manufacturers, as well as manufacturers of dynamo-electric machinery, have made numerous tests to determine contact resistances, friction losses, etc., of various carbons. While such tests are of interest, they contribute very little toward the real practical need; namely, a carbon that can stand high-current densities and high-sparking voltages with small wear.

In order to develop such carbons, it would seem essential to first make tests determining how the carbon wear is affected by current density, sparking voltage and peripheral speed. Present indications are that with many commercial carbons very appreciable densities can be used if there is no sparking voltage, while sparking voltages up to 15 or even 20 volts across the brush cause very little wear at certain speeds, if the current density is low enough.

More data along this line should be of great advantage to both the carbon manufacturer and the designing engineer. **R. E. Hellmund**, Engineer,
Westinghouse Elec. & Mfg. Co.

East Pittsburgh, Penn.

Ice Formation in Ponds

I have just been reading a back number of *Power*, the issue of Dec. 31, 1918, page 951, and note that in the article entitled "Ice in Hydro-Electric Plant," the author in explaining the freezing of water makes the following statement: "When the temperature of the whole body reaches 32 deg., ice begins to form on the surface."

My understanding is that the process described continues until the entire body of water reaches the temperature of about 39 deg. F., at which point water is at its maximum density. The surface of the water then continues to cool, but the circulation stops as the cooler water is now of less specific gravity than that in the lower levels. Ice forms as soon as the surface water reaches 32 deg. F. and has given off its latent heat.

Indianapolis, Ind. **Fred W. Clasmann.**

Threading a Short Pipe

The following "kink" may be of interest to others, so I am passing it on. To thread a pipe close to a bend or to thread a close nipple, reverse the dies in their sockets and use the stock in the reverse position but rotated in the right direction. This leaves no guide for the die, so to provide this use a short pipe of the size being threaded, having a good thread on one end, and insert it through the guide or follower and screw it into the die to act as a support. This can be held straight while the stock is turned and the thread started. When a few threads have been made, remove the guide pipe.

If plenty of oil is used, an excellent thread can be cut. Care should be taken to pull evenly on both handles or sides of the stock. **Herbert G. Stoddard.**

East Orange, N. J.

Air-Compressor Efficiency Improved

It was discovered that the intake pipe of an air compressor had parted sufficiently to permit the entire air supply to be taken from a point indoors, below the cylinder. A thermometer placed at the break showed a temperature of 100 deg. F., while the temperature out of doors was 47. Since the loss in efficiency equals about 1 per cent. for each 5 deg. rise in temperature of the air supply, it will be seen that the loss in this case was over 10 per cent.

This compressor carried a constant load, a smaller one taking care of variations, and after repairing the break an appreciable difference could be noticed in the load carried by the smaller machine.

Toronto, Ont., Canada. **R. McLaren.**

INQUIRIES OF GENERAL INTEREST

Motors and Lights on the Same Circuit—What are the objections to supplying electric motors and lamps from the same feeder provided they are of the same voltage? J. N.

The chief objection to this practice is that if the motors are started under heavy load, they will cause the voltage to drop to such an extent as to make the lamps fluctuate. The most satisfactory voltage for motor operation is 240 or higher, where lamps operate most efficiently around 120 volts. Consequently, if the motors are to be designed and operated at the higher voltage, the lamps must be operated in series groups, which to say the least is not satisfactory.

Effects of Voltage Increase on Power Transmitted—State the effects on the current, resistance, diameter and weight of wire resulting in the transmission of a given power load by increasing the voltage four times, the percentage of loss remaining the same in both cases. H. F. S.

Since the voltage is increased four times, the current will be decreased four times. The resistance of the conductors can be increased 16 times, which means that the cross-sectional area will be reduced by 16; consequently, the weight of the conductor will only be $\frac{1}{16}$ that on the higher voltage that it would be on the lower, and the diameter of the conductor will be reduced 4 times. The foregoing is possible in practice only where the insulation of the conductor is sufficient to withstand the increased voltage and the conductor has sufficient mechanical strength to meet the requirements of operating conditions.

More Wiredrawing of Steam With Earlier Cutoff—When earlier cutoff is obtained with a slide-valve engine by adding lap to the valve and advancing the eccentric, why is there more drop of the pressure during admission and more gradual cutoff, than with less advance of the eccentric? W. R. C.

Assuming that the engine shaft rotates at a uniform speed, the valve is moved at the highest velocity when the eccentric is at right angles with the eccentric rod, or neglecting angularity of the eccentric rod, the quickest movement of the valve in opening or closing and greatest opening would be obtained with no lap and no angle of advance. By advancing the eccentric and adding lap, the valve opens after it has passed the point in its travel where it has greatest velocity and is slowing down more and more as it nears the end of its stroke, and complete cutoff occurs when the valve has attained only the same velocity in its return stroke. Hence, the earlier the cutoff obtained by advancing the eccentric the slower and less the amount of opening, and the slower the movement of the valve as it closes, thus giving rise to wiredrawing of the steam during admission and more gradual cutoff.

Paralleling Discharge of Centrifugals—We operate two centrifugal units for supplying separate 16-in. service mains of a town and a mill water supply. The discharge of each centrifugal has a branch with check valve to each service main. It is found that both pumps cannot be made to discharge at the same time into the same main, as one will build up higher pressure than the other. Could not this trouble be overcome by removing the flaps from the check valves? H. A. T.

Closure of a check valve is an effect and not a cause of back pressure, and when a check valve becomes seated, somewhat greater intensity of pressure is required to raise the flap than that holding the valve to its seat, the difference depending on the design and size of the valve. To operate in unison, each pump must have a building-up capacity in excess of the margin necessary for opening the check valves, and to insure discharge from both centrifugals at the same time it is necessary to limit the discharge to the highest pressure that can be overcome by the weaker centrifugal, less the extra pressure required for opening the check valve on its discharge. The built-up pressure of either pump can be reduced to the selected standard by chopping down its discharge or by returning part of its discharge back to the suction. To save constant attention of an operator this can be accomplished by a discharge-pressure regulating valve, or by an automatically operated bypass valve.

Watts in a Three-Phase Circuit—In testing three-phase induction motors, we connect a single-phase indicating wattmeter in one phase, and then in one of the other phases; the sum of the two readings gives the total watts consumed. If all three phases are balanced, why could we not get the total watts by taking a reading in one phase only and multiplying it by 1.732? E. C. H.

Your statement that the sum of the wattmeter readings gives the total load in watts is only correct when the power factor is greater than 0.50. When the power factor is less than 0.50, the difference of the two readings gives the total watts. If the power factor is unity, the readings of a wattmeter connected in one phase and then in another of a balanced three-phase circuit would be the same, and the total power would be the sum of the two readings, or the reading of one multiplied by 2 and not 1.732, as suggested in the question. However, this can only be true for a balanced circuit having a constant load at unity power factor, since in every other case the two readings will not be the same value, and as stated in the foregoing must be added when the power factor is greater than 0.50 and subtracted when less. The constant 1.732 is used only to obtain the apparent watts in a three-phase circuit, which when circuit is balanced is $W = EI \times 1.732$ where W equals the total watts transmitted, E volts between terminals and I amperes per terminal.

Formula for Approximate Capacity of Pump—What is the derivation of the formula, $g = \frac{D^2LN}{294}$ for finding the number of gallons delivered by a pump? R. O. J.

In the formula quoted,

g = Number of gallons pumped per minute;
D = Diameter of plunger or piston in inches;
L = Length of stroke in inches;
N = Number of single strokes per minute.

The plunger or piston displacement in cubic inches per minute would be area of piston × length of stroke × number of single strokes per minute, or $D \times D \times 0.7854 \times L \times N$, and as one gallon equals 231 cu.in.,

$$g = \frac{D^2 \times 0.7854 \times L \times N}{231}$$

and dividing both numerator and denominator of the second term by 0.7854 gives

$$g = \frac{D^2 \times L \times N}{294.117}, \text{ usually written, } \frac{D^2LN}{294}$$

If N is taken to represent the number of revolutions of a single double-acting pump the result is to be multiplied by 2, and if N represents the number of revolutions of a duplex pump, which would be the same as two single pumps, the result must be multiplied by 4. It also must be borne in mind that the formula gives results larger than actual capacity of a pump, for it makes no allowance for reduction of capacity by slippage, and in double-acting piston pumps the displacement on one side of the piston is reduced by the presence of the piston rod.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Utilizing Waste in the Power Plant*

TO INCREASE the service capacity of power plants by utilizing the waste, it is first necessary to understand the term waste. As ordinarily used, it has several definitions, but in the present discussion it will represent the energy of generated power and labor that is lost by thoughtless labor, the lack of proper and systematic inspection or the want of thoroughness in design and distribution of the generated energy in all its component parts. The waste in power plants, especially in the average railway plant, will be found in two forms—wasted energy and wasted labor.

Wasted energy can sometimes be observed in the form of leaks, which may be easily found if looked for. However, even this saving can only be made after first locating and stopping the waste in labor. The first thing to look for in wasted labor is a way or method to get labor to read and think. It is useless for men to think always without reading, and it is just as deficient to read always without thinking. It has been said that a man who will read will be able to think out problems better than the man who rarely reads, as the reading man will have the added thoughts of his fellow workmen on his problems and will obtain suggestions that would never come to him in his daily work. No labor, clerical or mechanical, can do as efficient work with verbal orders as with written instructions, and the instructions should be illustrated when necessary to make the plan of their part complete and in harmony with the main working plan.

Utilizing the Waste Labor

If wasted energy is to be utilized to increase the power-plant capacity, it will be necessary to utilize the wasted labor first. This can be accomplished only by constant education. This education need not be by classes, such as the schoolroom, but should be thorough, first by keeping posted in a conspicuous place in all power plants a complete layout of all apparatus down to the smallest pipe lines for any service, as well as the wiring, and different colors to represent different transmission lines, for easy identification. This should be placed on a wall under a glass cover so that a man having any connection with the operation, repair, extension, reconstruction or inspection can know that his original instructions can be easily understood in detail by observation of the reference drawings.

With the continual change of men in power plants, the frequent extensions and renewals, there is rarely an employee that is sure of each and every detail of his own duty in handling his part of the work. The average new man receives a few verbal instructions from his immediate superior or from his predecessor and is left to work out his own salvation. If he is a student he will start to explore all parts of his operation from beginning to end and be sure that he understands when and where he will interfere with his colaborers. If not, he will cause considerable confusion, not only in his own work but with others.

When investigating a pipe line that has not been performing just as it should, how many have started out to find what the line was intended for originally, and before this information was obtained had to search several files and waste a lot of clerical labor as well as their own? If a diagram of the original and all extensions had been on the wall in a glass case, the information would have been available in a few minutes. Chiefs and superintendents will say, "The information is in my office." That may be true, but the men should have it continually before them to read and think about. It will not only encourage them, but make their hard problems so simple that they will be able to carry out work with less expense of time and damaged material than in any other way, and change in men will not cause the usual discord in the organization.

Labor, either executive or detail, cannot find wasted energy efficiently without complete information as to the designer's original plan and his estimate of detail results. With this information constantly before them, the workmen know what to do and can always make a more intelligent report as to results. Inspection, daily or periodical, can be made in far less time, and accurate information will be obtained that will further increase the employee's capacity to stop waste and convert it into capacity.

Wasted energy has been analyzed and talked of as much as any subject. Furnace and stack designs are usually given careful consideration, and where they have been neglected there are data available to correct the design and stop the waste.

Energy Wasted in Handling Coal

When considering losses it is surprising how much energy, both in labor and power, is wasted with every handling of coal. The coal dust that settles around a boiler room in a day, a month or a year gives a small indication. An easy estimate can be made by taking a given square area of space so it can be easily cleaned of all accumulated coal dust periodically and the accumulation weighed. On top of boilers the coal dust is, in many cases, inches deep. Of course this represents only a small percentage of the coal, but it takes such small effort to prevent this waste. A little water sprinkled on the coal when it is handled will stop the waste and the expense of cleaning it up. Some go to the other extreme; that is, they will waste a lot of water that has a value by putting so much on the coal that they stop up the drains with coal that is washed out of the pile. These thoughts direct the operator's mind to the necessity of handling coal as few times as possible and of dampening the coal when handling.

Daily inspection of the ashpile will give an indication of the amount of unburned coal. Water thrown on the ashes before inspection will make the unburned coke stand out prominently from the ash or noncombustible, giving something definite on which to start an investigation as to the cause of the waste.

When boiler settings are of brick construction, the outside walls should be covered with plastic cement which will fill up the pores or cracks in the setting, and all joints should be calked with fibrous insulating material which will prevent air infiltration. Regular inspection will be required to see that the cement is maintained intact. The walls of the setting should be thick enough and properly provided with insulation or air space to prevent the temperature of the outside brick from becoming excessive and causing abnormal heat loss by radiation. The top of the boiler should be covered with good insulating material and joined with the setting so that the expansion of the boiler will not open up the joints and let in air. Stopping waste at these points will materially increase the service capacity of the boilers. Metal boiler settings are not altogether free from air leakage and should be given the same careful attention. Stack and stack connections, as well as the connections between the boiler fronts and the settings, need watching to prevent air leakage.

Instruments Needed in the Power Plant

Grates should be selected for the kind and size of coal that is to be burned. The proper draft and the load for a given boiler setting and furnace condition may be determined by CO_2 instruments. Contrary to the general belief instruments of this kind can be used by other than highly trained technical men. There are draft gages on the market that can be read and interpreted by any fireman. There is a simple draft regulator that will maintain the position of the damper so perfectly balanced with the load that a recording steam-gage chart will look as though it were drawn with a pair of dividers. The instruments previously mentioned and a recording thermometer on the boiler feed-water lines are some of the instruments needed in any power plant if the wasted labor is going to be educated to know how to save the wasted fuel energy to increase the service capacity of the boiler plant.

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*Abstract of paper read by Edmund Burke of the Crane Company, before the Western Railway Club, Chicago.

Periodical tests are frequently used as a basis to determine the operating conditions in the plant. Tests will tell the operating conditions under fixed loads and maximum capacity, and are usually made under ideal conditions by men who do not duplicate the performance every day in the year. The tests that will turn the waste of the plant into service capacity are daily records made by the operating force, so that they will have something to study, and educate themselves each day under the working conditions. After that periodical inspection is good if it results in constructive criticism rather than fault finding.

Boiler trimmings should be selected with care, and regular inspection of the pop valves, water-gage columns, blowoff valves and fuse plugs will stop possible wastes that would reduce the service capacity materially.

Special fittings in pipe lines should be avoided as much as possible. All turns in high-pressure piping should be long-radius bends. The weight of fittings and valves should be governed more by the mechanical strains from the piping than the pressure strains, as the latter are far more destructive. The most important things to be considered in steam-pipe line design are the correct size and the layout to take up all mechanical strains. Waste caused by neglect of these items is difficult to locate and will seriously handicap the operator by not permitting flexible operation.

Few stop to consider the amount of money involved or loss of capacity caused by the small steam leaks around the power plant. The accompanying data offer a fair guide:

LOSS OF STEAM BY LEAKAGE

Gage Pressure	Loss of Steam Lb. per Hr. per Sq.In. of Leak	Cost of Loss per Month at 30c. per 1,000 Lb. for Steam
60	3,918	$846
75	4,676	1,010
100	5,925	1,280
120	6,936	1,498
140	7,932	1,713
150	8,787	1,898

Divide quantities in the table by the area of the leaks and the loss in any particular plant will be approximated. It will not require many leaky valve stems and few leaks around steam joints to make up a square inch of opening through which steam is flowing from the boiler to the atmosphere.

Numerous other wastes might be mentioned. The most important and the basic principle to correct all waste is periodical inspection and reports made out on a basis of educational development for the operators handling the equipment.

Biggest Annual Banquet of the W. S. E.

Jan. 22 was the date of the annual banquet of the Western Society of Engineers. It was held at Hotel Sherman, Chicago, and as the present year will see the fiftieth anniversary of the founding of the society, it was fitting that the attendance (465) should be the largest in the history of the organization. An excellent dinner interspersed with "ensemble" singing and an interesting program relating to the engineer's work in the war made up an enjoyable and profitable evening.

At a short business session preceding the speakers of the evening, B. H. Peck, electrical engineer of the State Public Utilities Commission, Springfield, Ill., was awarded the Chanute medal for the best paper presented to the society during the year. Announcement was also made of the award of the Alvord medal to Herbert C. Hoover, who had been chosen previously by a committee of the society as the engineer who had done most for the comfort and well being of humanity.

Charles B. Burdick, retiring president, recalled the fact that the fiftieth anniversary of the society was at hand and reviewed briefly the progress in engineering that had been made during the life of the organization. He said that one of the great aims of the society had been to promote engineering education. The one who prepares information for others benefits himself most. Technical discussion is of inestimable value in keeping up-to-date with the progress made in the profession. An engineer's best asset is to be well and favorably known and the society gives him the opportunity. The society should try to increase the compensation of engineers. Anything approaching trade unionism cannot be considered, but efforts to place engineers in public positions requiring engineering training and to insure good salaries are justified. Service could also be extended by helping to relieve unemployment among engineers.

In national affairs the engineer needs one mind and one voice. Reference was made to the movement originated by the four great founder societies in New York and of the invitation to membership extended to the Western Society and all local engineering associations of good standing.

Last year was a hard one, owing to the large number of engineers going into service. The loss of membership was excessive, but notwithstanding, the roll was increased more than during any year of the last decade. Creating new sections had been a great aid and it was the speaker's belief that provision for an industrial section would double the membership.

For the ensuing year the following officers were announced: President, A. S. Baldwin, vice president, Illinois Central Ry.; first vice president, Kempster B. Miller, consulting engineer; second vice president, W. M. Kinney, general manager of Portland Cement Association; third vice president, J. L. Hecht, mechanical engineer of Public Service Co. of Northern Illinois; treasurer, C. R. Dart, bridge engineer, Sanitary District; chairman of electrical engineering section, J. R. Cravath, consulting engineer; chairman of bridge and structural engineering section, G. A. Haggander, bridge engineer, C. B. & Q. R.R.; chairman of hydraulic, sanitary and municipal engineering section, Linn White, engineer of the South Park Board; chairman of mechanical engineering section, Fred J. Postel, engineer of the Board of Public Works, State of Illinois; chairman of gas engineering section, H. H. Clark, industrial gas engineer of Public Service Co. of Northern Illinois; trustee for three years, E. T. Howson, Western editor, *Railway Age;* trustee for two years, W. W. Deberard, Western editor, *Engineering News-Record;* trustee for one year, O. F. Dalstrom, bridge engineer, C. & N. W. Ry.

A. S. Baldwin, the incoming president, expressed the realization that the honor carried with it serious responsibilities and said that a disturbed condition existed throughout the whole world. It was reflected in all branches of society. Among engineers it was evident in the movement of the four founder societies to better conditions and to keep abreast of progress. Affairs of engineers were at flood tide. Never before had their ability been so widely recognized. They must now turn from war to work for the benefit of humanity. Those who had stayed at home now had exceptional opportunity to further the interests of the society and by doing so could do more for the profession than in any other way. In the coming year there should be unlimited opportunity for progress and all were requested to coöperate and join in the march forward.

Dr. E. H. Lewis, introduced as toastmaster, called upon Brig. General J. J. Morrow, Chief of Engineers, First Army, American Expeditionary Force, for the first address of the evening. The speaker told of the preparatory work in France and the accomplishments of the engineers while with the army, particularly in the Verdun Sector. He outlined the organization and enumerated the tasks and some of the experiences the engineers had while in service. On the whole the American engineer as a soldier, he said, was splendid, but due to the short period of training there were indications of a lack of discipline, a lack in knowing how to take care of things and a lack in accuracy of doing exactly what they were told to do. For the characteristic last named it was worth while for every engineer in civil life to develop and fit himself for military service. There had been also some difficulty in switching from the civil viewpoint of cost to the military idea of speed.

The final speaker of the evening was R. A. White, Chicago's famous travel lecturer, who gave an illustrated address on "War Conditions on the Western Front." The things he saw on the battlefield and the impressions he carried back were of exceptional interest.

Convention of Marine Engineers

The Forty-fourth annual convention of the National Marine Engineers' Beneficial Association was held at Buffalo, N. Y., during the week beginning Monday, Jan. 20, with headquarters at the Hotel Statler. There were 90 delegates present, representing 161 votes. They came from all parts of the United States and its possessions, including one each from Panama and Honolulu.

At the opening session on Monday morning the delegates were addressed by Mayor George S. Buck, who gave a brief, but interesting, history of the City of Buffalo, and cordially welcomed the convention. National President William S. Brown thanked the mayor for the nice things he said of the marine engineers and assured him that the address was doubly appreciated as the delegates were aware of how valuable the time of the mayor was.

Tuesday morning the delegates listened to an interesting talk by Mrs. August Molter, of the Women's Trade Union League, upon the aims and objects of that organization. William Kennedy, a charter member of the Cleveland Association No. 2, who has for 44 years been in active service for the uplift of the M. E. B. A., addressed the Tuesday afternoon session and was greatly appreciated.

The report of Treasurer Jones shows that the association is upon a firmer financial basis than ever before in the history of the organization. The increase in membership during the year 1918 was upward of 2500. During the week a charter was issued to Ocean Association No. 99, composed of deep-sea engineers.

A vote of thanks was tendered to the local association for its generous program of entertainment. There were many features of entertainment. On Monday evening there was a smoker at Elmwood Hall; on Tuesday evening the convention visited Shea's vaudeville theatre; on Wednesday there was a grand ball at Elmwood Hall, at which the attendance was fully 2000; Thursday morning a trip was made to Niagara Falls. All of the above were under the auspices of Local Association No. 1.

On Friday morning the convention, as guests of Mayor Buck and Fire Chief Murphy, enjoyed a trip around the harbor on board the fire tug "Gratten." On Thursday evening the National Marine Engineers' Supplymen's Association gave an entertainment and banquet at the Hotel Statler. Altogether the convention was voted as being among the best the M. E. B. A. ever had.

Early in the week the delegates elected national officers as follows: William S. Brown, president; John S. Purdie, first vice president; William H. Hyman, second vice president; Ed. C. Killian, third vice president; George A. Grubb, secretary; Albert L. Jones, treasurer. The executive committee comprises William S. Brown, Charles S. Follett, William T. Garrett, Robert L. Goelet, Ed. C. Killian, Charles M. Sheplar.

The newly elected officers of the Supplymen's Association include: J. J. Cizek, The Leslie Co., president; Andrew Lauterbach, The Lunkenheimer Co., vice president; Charles A. Wilhoft, New York Belting and Packing Co., secretary-treasurer.

The selection of the next convention city is left to the discretion of the executive committee to be decided upon in July next.

Foreign Trade Promotion

Previous to the war and owing to the conditions existing in the mercantile marine, comparatively few of the manufacturers of this country sought foreign markets and those who did held to a rigid system of credit protection. In Latin America an erroneous impression prevailed as to the integrity of America's business methods. But the war changed these conditions with the closing of the markets of Europe, and our trade with the twenty countries of South America increased from $750,000,000 in 1913-14 to $1,750,000,000 in 1917-18.

Our larger banking institutions, principally in New York City, established branches in all the countries of South America and the people of these countries have come to appreciate the service offered them by our financial institutions. Thus we are today in a position to compete as never before for this desirable business. For those interested in foreign-trade expansion the Bureau of Foreign and Domestic Commerce of the Department of Commerce has evolved an elaborate plan of information regarding export business, and is prepared to furnish data as follows:

Foreign Tariffs — Information concerning foreign tariff and customs laws and regulations, commercial policies of foreign countries, foreign trademarks and patent laws, embargoes and import prohibition, and foreign consular regulations.

Research — Supplies information on import and export statistics of all foreign countries, foreign sources of supply of raw materials, translating, and researches in all phases of foreign trade.

Statistics — Supplies information regarding import and export statistics of the trade of the United States with all countries. These statistics are furnished in ten-day, monthly, quarterly and yearly periods.

Far East—Information regarding ports and transportation facilities, investment opportunities, mineral resources and their development, and the markets for cotton goods, wearing apparel, railway equipment, motor vehicles, shoes and leather, etc.

Latin America — Information concerning markets for American products, regulations for guidance of commercial travelers, trade conditions in Latin America, specific openings for American exports, and concerns which might act as representatives of American exporters.

Correspondence — Furnishes American exporters information on markets in foreign countries, including advice on methods of packing, financing export shipments, sources of foreign credit data, lists of importers abroad, and names of domestic manufacturers.

Editorial—Makes available to the business public, through publications and indexes, information on commercial and industrial conditions in all parts of the world.

District Offices—Miniature bureaus at New York, Boston, Chicago, St. Louis, New Orleans, San Francisco and Seattle. Recognized centers for reliable information regarding domestic and foreign trade. Render special service to foreign buyers seeking goods in the United States, and adjusting trade differences.

Commercial Attaches—Located in the principal capitals of the world, furnish first-hand information and advice on banking, commercial, industrial and investment conditions abroad.

Special Agents—Technical trade investigators who study foreign markets for specific American commodities, also assist American manufacturers and exporters to establish satisfactory trade relations with particular foreign importers.

Trade Commissioners — Men with commercial and economic training who study general trade conditions abroad, with particular reference to increased sale of American products, supplying the raw materials necessary in American industries, etc.

Flywheel Explosion in St. Louis

In a rolling mill operated by the American Car and Foundry Co., in St. Louis, a flywheel exploded, damaging the building in which it was located and several adjacent buildings, the property damage totaling about $3000. Fortunately, no one was injured. The flywheel was 9 ft. in diameter, with an 8 x 8-in. rim section and was bolted to the crank shaft in halves. The engine to which it belonged is of the old-fashioned throttle-valve Buckeye type, running 120 r.p.m., with cylinder dimensions 12 x 30 in. It was belted to a lineshaft from which a set of blowers and other auxiliary apparatus were driven.

The explosion can be traced to no definite cause. At the moment of its occurrence the chief engineer was examining a shearing machine remote from the engineroom. He heard two preliminary muffled reports, as of a powder blast, followed instantly by the loud crash of the disrupting wheel, but he observed no irregularity in the running of the shafting. The governor was found in working order, and the belt which drove it was intact.

Obituary

Abram T. Baldwin, president of the Precision Instrument Co. of Detroit, Mich., died on Jan. 8.

Burt O. Gage, superintendent of the Warren (Mass.) Steam Pump Co., widely known as an inventor and pump expert, died at his home in Warren, Mass., Jan. 9, after a few days illness, of bronchial pneumonia. He was in his 76th year. He had been associated nearly all his life with the pump industry, entering the employ of the Knowles & Sibley Co., manufacturers of steam pumps, in 1867. For about forty years he was associated with this concern and its successors, the George F. Blake Manufacturing Co., of Warren and Boston, during which time he patented many useful and practical ideas in pumping machinery. In 1905, he became associated with the Warren Steam Pump Company, as superintendent. He had travelled extensively throughout the country, having charge of many water-works installations. At the time the cruiser "New York," now the "Rochester," was being planned, Mr. Gage helped to successfully develop a vertical type of pump occupying small floor area and known today in the pump trade as the vertical twin air pump. This type of pump is still in successful use on naval vessels. After becoming connected with the Warren Steam Pump Co., he invented a valve gear for direct-acting single pumps. He was also the originator and patentee in the use of monel sheets as pump liners.

Personals

Charles C. Enderle, who has been in the engine sales department of the Ball Engine Co. for some years, is now in charge of the Philadelphia district, with offices at 621 Commercial Trust Building, Philadelphia.

Herbert W. Gledhill, who was formerly sales engineer at the Philadelphia office of the Shepard Crane and Hoist Co., has been made district manager of that office, with Glenn Rumsey and Leland Woodworth as assistants.

Charles R. Emerson has been appointed general sales manager of the Foster Engineering Co. He was formerly manager of the company's Boston office for two years and manager of the Philadelphia office for the last six years.

Captain Edward E. Ashley, Jr., for many years consulting mechanical and electrical engineer for Starrett & Van Vleck, Architects, New York City, has resigned his commission in the Air Service of the United States Army, to accept appointment as sales engineer of the Mercury Manufacturing Co., Chicago, manufacturers of electrically-driven tractors for use in connection with industrial haulage systems.

Engineering Affairs

The American Association of Engineers had the St. Louis Chapter installed at a banquet at the Planters Hotel on the evening of Jan. 18 with about 150 members enrolled.

Liberty Association No. 15 of the National Association of Stationary Engineers, which was formerly the First German Association of Stationary Engineers of Cincinnati, Ohio, is doing good work, as its educational program for the coming season shows: On Jan. 25, J. W. Fowler will speak on "Flue Gas Analysis and Its Relation to Boiler Efficiency;" Feb. 8, "Powdered Coal as Furnace Fuel," by Theodore Nielander; Feb. 22, "Steam Jet Ash Conveyors," illustrated with lantern slides, by William E. Muse; Mar. 8, "Ventilation and Heating of Buildings," by A. M. Robinson; Mar. 22, "Care of Electrical Equipment," by Charles F. Kleine; Apr. 5, "Power Plant Efficiency," by R. W. Parry; Apr. 19, "Sawdust, Offal and Tanbark as Fuel," by Judson Pratt. All meetings will be held in the hall of the association, 519 Main St., at 8 p. m.

Miscellaneous News

The Indiana Power and Water Co., Vincennes, Ind., will expend approximately $150,000 for improvements. It is the intention to supply power and light to the Illinois oil fields to the west of Vincennes by stringing three 33,000-volt wires across the Wabash River, spanning the stream from one of the main streets of Vincennes. The power is to be sold to the Central Illinois Public Service Co. which is to supply territory near Lawrenceville, Brideport and Stoey, Ill., with power and light and to provide residents along the proposed route with power and light as well.

The Bureau of Labor of the United States Fuel Administration will continue to function until the proclamation of peace, it was announced recently.

Under an agreement published July 23, 1918, all labor questions pertaining to the coal-mining industry were placed definitely under the jurisdiction of the Fuel Administrator, this arrangement having the sanction of the Secretary of Labor and of the United Mine Workers of America. The agreement included the provision that any dispute failing of settlement between the parties at interest must be submitted to the Fuel Administration for final disposition without stoppage of work.

Fatal Tube Failure in St. Louis—At the Purina Mills, St. Louis, Mo., on Jan. 15, a tube failure in a 250-hp. water-tube boiler resulted in the death of two men. The engineer, who was standing in front of the furnace, was almost instantly killed, and the fireman was so badly scalded that he died two days later in the hospital. The boiler was equipped with 3½-in. tubes. The accident resulted from the wearing away of the external surface of the tube by attrition. The tube split open for a length of about 24 inches. As the result of an inspection following the explosion, the entire set of tubes was renewed, many of them having been found worn to less than $\frac{1}{32}$ in. thickness. The boiler was installed about twenty years ago, and had been run continuously with the original set of tubes. It was practically free from scale, and there was no evidence of tube-corrosion, neither internally nor externally.

The United States Shipping Board wants at once 500 American seamen of more than two years' experience on deep water, and five hundred mechanics with engineering experience, to be trained as deck officers and marine engineers respectively, for the Merchant Marine. The seamen will be trained in navigation at twenty-one free navigation schools maintained by the Board, and the mechanics at free courses in technical colleges or at the special marine engineering schools of the Board. Stationary and locomotive engineers, machinists, who have worked on marine engines and marine oilers and water tenders will be accepted for the engineering courses. When the sailors have completed a six weeks' course of study and the engineers a month's course, they will be examined for licenses as third mates and third assistant engineers respectively, and sent to sea. Engineering schools are maintained at Massachusetts Institute of Technology, Cambridge, Mass.; Pratt Institute, Brooklyn; Seaman's Church Institute, New York; Dickinson High School Building, Jersey City; The Bourse, Philadelphia; Armour Institute, Chicago; Case School of Applied Science, Cleveland; University of Washington, Seattle; University of California, Berkeley, and Tulane University, New Orleans. The navigation schools are at the chief coast and lake ports, and their addresses will be furnished applicants by the U. S. Steamboat inspectors, or by the Sea Service Bureau agents of the Shipping Board at the various ports. General information about the schools will be furnished by Henry Howard, Custom House, Boston.

Trade Catalogs

Ross Power Equipment Co., Indianapolis, Ind., has issued its Bulletin No. 9, which supersedes previous bulletins, and gives a partial list of its available new and used equipment for sale, for steam and electric plants.

Ladew Leather Belting. Edw. R. Ladew Co., Inc., New York City. An attractive and interesting 108-page catalog, 6 x 9 in., fully illustrated, with several pages devoted to a discussion of belt engineering and belting economics. A free copy may be had upon request.

Foxboro Power Plant Instruments. The Foxboro Co., Inc., Foxboro, Mass. Bulletin 115. A condensed bulletin briefly covering the company's instruments manufactured especially for use in power plants. A copy may be had free upon request.

New Construction

PROPOSED WORK

Mass., Montague City—The Turners Falls Power & Electric Co., Turners Falls, plans to install another unit in its power house here. Plans are also being prepared for a 44 x 48 x 55 ft concrete, steel and brick addition to its present building and for raising concrete canal walls about 2 ft. for distance of 5000 ft.

Mass., New Bedford—The Board of Education will install a steam heating system in the 2 story, 117 x 155 ft. school building which it plans to build on Emery St. Total estimated cost, $185,000. F. C. Brown, Chapman Bldg., Arch.

Conn., Hartford—Libby, McNeil & Libby, 252 Asylum St., will soon receive bids for the construction of a 3-story, 50 x 112 ft., cold storage plant on Edwards St. Estimated cost, $60,000. Philip Larmon, c/o Swift & Co., Union Stock Yards, Chicago, Ill., Engr.

Conn., New Britain—The State plans to install a vacuum heating system in the 2 story, 64 x 110 ft. school house which it plans to build on Camp St. Total estimated cost, $100,000. C. D. Hine, Hartford, State Supt. Davis & Brooks, Lewis and Gold St., Hartford, Arch.

Conn., Willimantic—The State plans to install a steam heating system in the 3-story, 46 x 114 and 30 x 46 ft. dormitory which it plans to construct on Valley St. Total estimated cost, $150,000. C. D. Hine, Hartford, State Supt. Davis & Brooks, Lewis and Gold Sts., Hartford, Arch.

N. Y., Albion—The Directors of the State Home for Refuge for Women, Albany, have applied to the State Legislature for an appropriation of $10,000 for installing new heating line and equipment and $10,000 for covering of steam lines and mains at the home here; $30,000 for building a cold storage and ice making plant.

N. Y., Bath—The Directors of the New York Soldiers & Sailors Home have applied to the State Legislature, Albany, for an appropriation of $24,000 for new electric construction, consisting of a new A.C. generator, engine, switchboard, voltage regulator, etc., new underground feeders, and transformers; also $89,200 for new heating construction, consisting of 4 new boilers, new underground heating, line, hot water plant, etc.

N. Y., Brooklyn—The Directors of the Williamsburg Hospital, 342 Bedford Ave., will install a steam heating system in the 7-story, 126 x 150 ft. hospital which they plan to build on South 9th St. and Driggs Ave. Total estimated cost, $350,000. Helmle & Corbett, 190 Montague St., Arch.

N. Y., Central Islip—The State Hospital Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $80,000 for building an addition to the store house and refrigerating plant and $10,000 for 3 new boilers and piping at the Central Islip State Hospital.

N. Y., Hudson—The Directors of the N. Y. State Training School for Girls have applied to the State Legislature, Albany, for an appropriation of $48,000 for building a refrigerating plant and store house.

N. Y., Industry—The Directors of the N. Y. State Industrial School have applied to the State Legislature, Albany, for an appropriation of $20,000 for improvements to heating system.

N. Y., Iroquois—Bids will be received until Feb. 15 by W. Hunt, Pres. of the Bd. of Managers, Thomas Indian School, for installing refrigerating equipment. Estimated cost, $10,000.

N. Y., Jay—The Au Sable Forks Electric Co., Inc., Au Sable, plans to build an electric-light plant here. Estimated cost, $25,000.

N. Y., Newark—The Directors of the New York State Custodial Asylum for Women have applied to the State Legislature, Albany, for an appropriation of $10,000 for installing a low pressure heating main through the tunnel.

N. Y., New York—C. Muller, Rockaway Park, will install a steam heating system in the 4 story, 100 x 200 ft. garage which will be built on West Dykman St., west of Sherman Ave. Total estimated cost, $100,000. Joseph T. Powers, 220 Larker St., Rockaway Park, Arch.

N. Y., Ogdensburg—The State Hospital Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $[illegible] for increasing the boiler capacity in the St. Lawrence State Hospital.

N. Y., Ossining—The State Prison Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $[illegible] for installing new refrigerating apparatus in Sing Sing prison.

N. Y., Poughkeepsie—The State Hospital Commission, Capitol, Albany, will install one [illegible] h.p. motor and one pump in the Hudson River State Hospital in connection with the alterations and additions which it plans to make. Total estimated cost, $40,000. L. F. Pilcher, State Arch.

N. Y., Rochester—The State Hospital Commission, Capitol, Albany, has applied to the State Legislature for an appropriation of $[illegible] for building an addition to power house and $35,000 for installing an automatic sprinkler system in the Rochester State Hospital.

N. J., Newark—The Board of Education plans to build a power house in connection with the 4 story, 200 x 200 ft. Vocational School for Boys which it plans to build on Sussex Ave. and 1st St. Total estimated cost, $500,000. J. H. and W. C. Ely, Firemans Bldg., Arch.

N. J., Newark—Peter Hauck, 85 Clifton Ave., will install power equipment in his factory for the manufacture of nut butter. Lockwood Greene & Co., 101 Park Ave., New York City, Engr.

Penn., Avella—The Washington County Dairy & Produce Co. plans to build a 20 ton ice plant and install electric power generator in order to furnish light for the city of Avella. The company is in the market for engines and refrigerating machinery. J. A. Taylor, Mgr.

Penn., Mauch Chunk—M. G. Prutzman, Court House, plans to build an electric light plant.

D. C., Georgetown—The Fussell-Young Ice Cream Co., 12th and V St., has had plans prepared for the construction of a 40 x 60 ft. power house. Estimated cost, $25,000. Van Rensaeler H. Green, 154 Nassau St., New York City, Engr.

D. C., Washington—The International Association of American Machinists, 9th St. and Massachusetts Ave., plans to install a steam heating system in the 5 story, 68 x 100 ft. office and loft building which it plans to construct on 9th St. and Mt. Vernon Pl. Total estimated cost, $150,000. Melburn, Heister & Co., Engr.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until Feb. 17 for installing machinery, equipment and piping for the power plant here; Specification No. 3328. Estimated cost, $125,000.

Ga., Lyerly—J. S. Owings has purchased the Sarling Mill property here and plans to build an electric light and power plant.

Fla., Bunnell—The city voted in favor of a $15,000 bond issue for the construction of an electric-light plant. Address the Mayor.

Ala., Selma—The city plans to build an electric light plant. Louis Benish, Mayor.

Ohio, Cleveland—The Clover Meadow Creamery Co., Crawford Rd. and Hough Ave., will install steam heating system, refrigeration plant and two 60 h.p. boilers, etc., in the 2 story creamery which it plans to build at 1827 East 55th St. Total estimated cost, $60,000. Walter G. Caldwell, 1206 Williamson Bldg., Arch.

Wis., Ladysmith—The Ashland Light, Power & Railway Co. plans to build a hydro-electric plant on the Flambeau River. Estimated cost, $1,750,000. L. E. Meyers, 53 West Jackson Blvd., Chicago, Ill., Engr.

Iowa, Cherokee—The Sache & Bunn Co., 322 3rd St., will install a boiler and heating and radiation systems in the 2 story, 32 x 80 ft. storage building which it plans to build. Total estimated cost, $30,000. Beuttler & Arnold, 610 Security Bldg., Sioux City, Arch.

Minn., Cloquet—The Board of Education will install a ventilation system and steam heating equipment in the 3 story, 65 x 190 ft. school which it plans to build on Main St. Total estimated cost, $140,000. Croft & Boerner, Lansdale Bldg., Duluth, Engr.

Minn., Duluth—The Protestant Church Trustees, Morgan Park, will install a complete steam heating plant and mechanical ventilation system in the 2 story church which they plan to build on Commonwealth Ave. Total estimated cost, $100,000. Gorman & Jenssen, Exchange Bldg., Engr.

Minn., Little Falls—The Little Falls Power Co., Little Falls, plans to extend its transmission lines into Aldrich to supply the village with light. T. C. Gordon, Mgr.

Minn., Little Fork—The Little Fork Light & Power Co., Inc., plans to build an electric light and power plant. E. Folkinghorne is interested.

Minn., Mountain Iron—The Board of Education will install a steam heating system with temperature control, also electric equipment in the 2 story, 131 x 156 ft. grade school which it plans to build in Leonidas Twp. Total estimated cost, $175,000. H. E. Mitchell, Secy.

Minn., Mountain Iron—The Board of Education plans to install a steam heating system and electrical equipment in the 3 story, 145 x 173 ft. technical grade school which it plans to build on Main St. Total estimated cost, $700,000. H. E. Mitchell, Secy.

Kan., Oswego—The city plans to take over and rebuild the plant of the Oswego Light, Power & Supply Co., and install electrical equipment to do the pumping of the city water system. J. M. Rings, Mgr.

Mo., Macon—The city voted in favor of a bond issue for $15,000 for water-works and electrical improvements.

Mo., Sikeston—The city plans an election in April to vote on a bond issue to build an electric light plant. Address the Mayor.

Tex., San Antonio—The Construction Division of the War Department, Washington, D. C., has authorized the enlargement of the refrigerating plants at Camp Travis and Fort Sam Houston Hospitals. Estimated cost, $10,000. Work will be done under the direction of Major F. G. Chamberlain, Construction Quartermaster.

Okla., Marietta—The city plans an election soon to vote on a bond issue for improvements to the water-works and electric light plant.

Cal., Bakersfield—The Southern California Edison Co., 301 South Broadway, Los Angeles, has had surveys made by E. F. Prouse, Asst. Engr., for a large hydro-electric plant, to include construction of a dam, in Hern River Valley. Estimated cost, $10,000,000. W. Dennis, Ch. Engr.

Cal., Tulare—The Mt. Whitney Power & Electric Co., 215 West Main St., Visalia, plans to expend $60,000 for extending lines to farmers pumping plant; $1700 for converting lines in Tulare from 2 phase, 6000 volts, into 3 phase, 11000 volts; also $5000 to install one 500 k.w., 11,000 volt transformer and one300 k.w., 200 volt transformer in the Tulare substation. F. G. Hamilton, Supt. West Div.

N. S., Antigonish—The Town Council plans to rebuild its electric light plant which was destroyed by fire. Estimated cost, $40,000.

N. B., Sussex—Charles T. White & Son, Ltd., is in the market for a 3-phase alternating generator, 1000 light capacity.

Ont., Alvinston—The Hydro-Electric Commission of Ontario, University Ave., Toronto, is receiving bids for remodeling the electric light plant and system, consisting of new steam boilers and interior and exterior wiring. F. A. Gaby, Engr. Noted Jan. 14.

Ont., St. Marys—The St. Marys Wood Specialty Co. is in the market for hydro motors, 10 to 30 h.p.

Ont., Toronto—The Dominion Shipbuilding Co., foot of Bathurst St., plans to build a boiler house and make other improvements to its plant.

Sask., Gravelbourg—Sam Chevrier plans to install an electric light plant. Estimated cost, $40,000.

Sask., Melfort—The Saskatchewan Co-operative Creameries plan to build a cold storage plant and creamery and are in the market for machinery and equipment. James Rutledge, Mgr.

Sask., Saskatoon—The City Council plans to build an addition to its water-works and is in the market for turbines, machinery and other equipment for the plant. Andrew Leslie, Clk.

CONTRACTS AWARDED

Ariz., Ajo—The Ajo School District No. 15 received lowest bid for installing plumbing and steam heating system in the proposéd 2 story school, from Horrall & Bellas, 523 West Van Buren St., Phoenix. Estimated cost, $14,996.

N. S., Halifax—The Dominion Government, Ottawa, Ont., has awarded the contract for the construction of a power house and laundry for the Military Hospital at Camp Hill, to Rhodes, Curry Co., Ltd., Amherst. Estimated cost, $210,565.

THE COAL MARKET

BOSTON—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$[illegible]
Rice	2.90	Barley	2.40

All rail to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.45 to $8.90.

NEW YORK—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	[illegible]
Buck	5.10	5.90	Egg	7.70	[illegible]
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

PHILADELPHIA—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

CHICAGO—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine run	2.35—2.50	3.00—3.15
Screenings	2.05—2.30	2.75—2.90

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

ST. LOUIS—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10. other rates p. 95.

PRICES—MATERIALS AND SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft. Lengths
Underwriters' 2½-in.	80c. per ft.
Common, 2½-in.	30%

Air	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.55	$0.40	$0.30

Steam—Discounts from List

First grade	25%	Second grade	35%	Third grade	40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	50%	Best grade	30%
Standard	40%		

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	35%	35%
Denver	35–5%	30%

RAWHIDE LACING—50% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1 20
Flax, waterproofed	1.60
Compressed asbestos sheet	1 00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure		Llist
For low-pressure heating and return lines	4-ply	58% off
	3-ply	60% off
	2-ply	62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5¼	6 9	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4 1	3¾	5¼
Gear	4½	9	4½	9 5	8	9
Car journal	22(gal.)	21 (gal.)	3½	4.5	5	8

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13¼ x 13¼	13¼ x 20½
Cleveland	$52.00	$58.00
Chicago	48 00	50 00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw in barrels	$1 49	$1 28	$1 90	$1 30	$1 65	$1.26
5-gal. cans	1.74	1.38	2.00	1.40	1.86	1.35

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13 00	14 50	12 25	12 50	13 00	12 50
25- and 50-lb. kegs	13.25	14 75	12 50	12 75	13 25	12 75
12½-lb. keg	13.50	15 00	12 75	13 00	13 50	13 00
5-lb. cans			14 25	14 00	15 00	14 50
1-lb. cans			14 25	14·50	16 00	14 50

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. carboys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel $\frac{7}{16}$ and smaller	40%	45–5%	40%
Tinned	30%	45–5%	40%

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York...$5.675 Cleveland...$5.15 Chicago...$5.67 Pittsburgh... 4.65

Coneheads, same sizes:

New York...$5.775 Cleveland...$5.25 Chicago...$5.77 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00	at Chester, Penn.
Chrome cement	net ton	65.00	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48	at Clearfield, Penn.
Magnesite, dead burned	net ton	37.50	at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	90.00	at Chester, Penn.
Silica brick	net ton	45–55	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL — Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	70.00	80.00	93.00	75.00	70.00
Commercial	42.00	40.00	21.50	22.00	15.00	25.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.50
Chicago	19.00	15.00

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft	7.65	6.85	6.10	6.85
7 in. by 35 ft	11.10	10.00	8.95	10.00
8 in. by 35 ft	12.65	11.35	10.10	11 35
7 in. by 40 ft	12 85	11.50	10 20	11 50
8 in. by 45 ft	18.90	16.90	15.00	16 90
8 in. by 50 ft	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft	$9.00
12-in. butts, 6-in. tops, length 30-40 ft	11.50
12-in. butts, 6-in. tops, length 41-50 ft	12.50
14-in. butts, 6-in. tops, length 51-60 ft	21.00
14-in. butts, 6-in. tops, length 61-71 ft	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

	Steel			Iron	
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼, and ⅜	47%	20½%	¾ to 1½	36%	20%
½	51%	36½%			
¾ to 3	54%	40½%			

LAP WELD

2	47%	34½%	2	29%	15%
2½ to 6	50%	37½%	2½ to 6	31%	18%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	43%	25½%	¾ to 1½	36%	21%
½	48%	35½%			
¾ to 1½	52%	39½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	45%	33½%	2	30%	17%
2½ to 4	48%	36½%	2¼ to 4	32%	20%
4½ to 6	47%	35½%	4½ to 6	31%	19%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	43%	27%	43%	26%	41 1%	26 1%
3½ to 3 in steel lap welded	38%	29%	39%	23%	37 1%	23 1%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%. Cast iron, standard sizes, 10% off.

BOILER TUBES—The following are the prices for carload lots, f.o.b. Pittsburgh.

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	17	3½ to 4½ in.	15½
2½ to 3¼ in.	27	3 to 3¼ in.	+ 2
2¼ in.	20½	2½ to 2¾ in.	+ 4½
1¾ to 2 in.	16	2 to 2¼ in.	+ 19
		1¾ to 1¾ in.	+ 32

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$334	1¾ in.	$214
1¼ in.	274	2 to 2¼ in.	184
1½ in.	264	2½ to 3¼ in.	174
1¾ in.	214	4 in.	194
		4½ to 5 in.	214

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104 00	$138 00	$164 00	$222 00
No. 12 solid	135 00	170 00	211 00	290 00
No. 10 solid	185 00	235 00	255 00	325 00
No. 8 stranded	235 00	325 00	345 00	450 00
No. 6 stranded	370 00	472 00	625.00	

From the above lists discounts are:

Less than coil lots	Net List
Coils to 1,000 ft	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0 40
12 to 50	38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜			$18 24	$19.38	$5.76	$6 12
½	$76 50	$81 60	18 24	19.38	6.72	7.14
¾	101.20	108 10	24 00	25.50	9.60	10.20
1	149 60	159.80	35.52	37.74	12.48	13.26
1¼	202.40	216.20	45 45	48 15	17.17	18.19
1½	242 00	258 50	60 60	64 20	21 21	22 47
2	325 60	347 80	111.11	117 70	28 28	29 96
2½	514 80	549 90	181.80	192 60	40 40	42 80
3	673 20	719 10	484 80	513 60	60 60	64 20
3½	837 20	892.40	1,070 60	1,134 20	80 80	85 60
4	1,013 70	1,079 10	1,237.25	1,310.75	101 00	107 00

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
7/32	250	$0.05½	Coils . . 55% Off. . Less coils, 40% off
¼	250	06	
⅜	250	.09	
½	200	.12	
⅝	200	15	
¾	150	.18	
1	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities

CUT-OUTS, PLUG

S. P. M. L.	$0 11	T. P. to D. P. S. B.	$0 24
D. P. M. L.	18	T. P. to D. P. T. B.	38
T. P. M. L.	26	T. P. S. B.	33
D. P. S. B.	19	T. P. D. B.	54
D. P. D. B.	37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp	31-60 Amp	60-100 Amp
D. P. M. L.	$0 33	$0 84	$1 68
T. P. M. L.	.48	1.20	2 40
D. P. S. B.	42	1 05	
T. P. S. B.	.81	1.80	
D. P. D. B.	.78	2.10	
T. P. D. B.	1.35	3 60	
T. P. to D. P. D. B.	.90	2.52	

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22 00
No. 16 cotton twisted	28 40
No. 18 cotton parallel	25 00
No. 16 cotton parallel	32 00
No. 18 cotton reinforced heavy	35 00
No. 16 cotton reinforced heavy	42 00
No. 18 cotton reinforced light	30 00
No. 16 cotton reinforced light	36 00
No. 18 cotton Canvasite cord	29 00
No. 16 cotton Canvasite cord	35 00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp	100	$0.25
35-amp. to 60-amp	100	.35
65-amp. to 100-amp	50	.90
10-amp. to 200-amp	25	2.00
25-amp. to 400-amp	25	3.60
2-map. to 600-amp	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	40
35-amp. to 60-amp.	100	60
65-amp. to 100-amp.	50	1 50
110-amp. to 200-amp.	25	2 50
225-amp. to 400-amp.	25	5 50
450-amp. to 600-amp.	10	8 00

Discount: Less 1-5th standard package	30%
1-5th to standard package	40%
Standard package	52%

FUSE PLUGS, MICA CAP

0-30 ampere, standard package	$5 25 C
0-30 ampere, less than standard package	7 00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B Watts	Plain	Frosted	No. in Package	Mazda C Watts	Clear	Frosted	No. in Package
10	$0 35	$0.38	100	75	$0 70	$0 75	50
15	.35	38	100	100	1 10	1 15	24
25	.35	38	100	150	1 65	1 70	24
40	.35	38	100	200	2 20	2.27	24
50	35	38	100	300	3 25	3.35	24
60	40	45	100	400	4 30	4 45	12
100	85	92	24	500	4 70	4 85	12
				750	6 50	6 75	8
				1000	7 50	7 75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

		Each
Hubbell, porcelain No. 5406,	standard package 250	$0 24
Hubbell composition No. 5467,	standard package 50	32
Benjamin swivel No. 903,	standard package 250	20
Hubbell current taps No. 5638,	standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$13 00	$16 00	$18 00	$32 00
12	16 70	18 80	22 00	36 85
10	23 52	26 10	29.10	50 60
8	31 00	36 40	40 20	70.10
6			62 00	
4			83 10	
2			122 40	
1			161 30	
0			189 68	
00			230 00	
000			282 40	
0000			345.50	

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$15.00	$19 00	$38 40	$21 00	$16 00	$33 00	$13 00	$17.40	$36.80
10	22.65	29 05	58 25	27 20	31 00	69 00	21 40	24 40	42.75
8	31.95	39 20	78 65	38 00	42 00	78 00	42 35	44 35	
6	54 40	58 10			65 00	130.00	64 60	74 60	
4	77 50	83 00			93 00		101 75	106 05	
2	115 30	123 50			140 00		151 50		
1	150 05	161 20			182 00		201.00	258 50	
0		179 05			242 00		276.00	285 00	
00		243 35			290 00		317 00	330 00	
000		296 65			360 00		417.00	428 50	
0000		361 50			435 00		516 00	516 00	

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

⅜ In. or Pendant Cap.			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0 60	$0 39	$0.36	$0 66

Less 1-5th standard package	+20%
1-5th to standard package	- 10%
Standard package	–15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	50c. lb
No. 18 B.&S. regular 1-lb. coils	52c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb
Soldering paste, 2 oz. cans Nokorode	$1.20 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0 42	$0 68	$1 02	$1 36
60	74	1 22	1.84	2 44
100	1.50	2 50	3 76	5 00
200	2 70	4 50	6 76	9 00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1 06	1 60	2.12
60	1 18	1 80	2 70	3.60
100	2 38	3 66	5 50	7.30
200	4.40	6.76	10 14	13.50

Discounts:

Less than $10 00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%

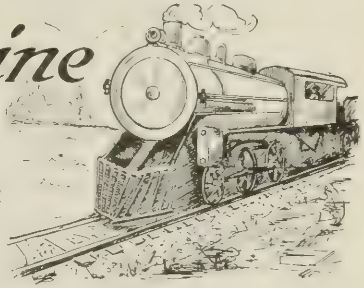
POWER

Volume 49 New York, February 11, 1919 *Number* 6

Andy's Engine

By

James T. Beard, Jr.



THE character of a musician is reflected in his sonatas; an architect, in his buildings; a poet, in his verses. The individuality of every man creeps into his work, and by his work we judge him. The boiler room furnishes a mirror, reflecting the character of a chief engineer. The heat that he is able to squeeze out of the coal and into the steam is the true standard of his capabilities, but a quick indication of his intelligence is the care that he takes of the equipment for squeezing out this heat.

I was standing at the station in a typical small Jersey town, waiting for a train to carry me back to the city. Presently I heard the welcome sound of a whistle far down the track. The station attendant ran out with a few mail bags, and I picked up my grip, glad that my half-hour wait was over.

As the train approached it seemed to me that it was not going to stop. I was not acquainted with the schedule of the road, so I asked the boy, "Does this train stop, or is she an express?"

He looked up, surprised. "Don't you know that engine?"

I explained that I was not an authority on locomotive engines in the country.

He looked at me with a sort of pity for my ignorance. Then he pointed down the track. "See the way she shines when the sun hits her? That's Andy's engine. I'd know her in a thousand. He takes care of her just as if she was his own."

The train stopped. I climbed aboard and settled down in my seat. The boy's words still haunted me: "I'd know her in a thousand. He takes care of her just as if she was his own." This youngster had unconsciously given a wonderful testimony to Andy's ability as an engineer and character as a man. "He takes care of her just as if she was his own." In these few words he had written for Andy the best recommendation in the world.

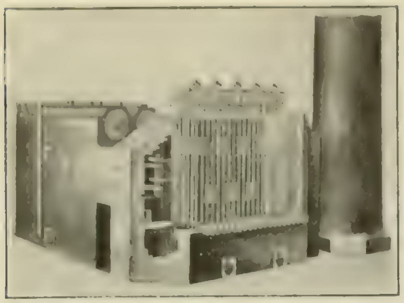
I began to think of some of the boiler rooms I had seen during the past month. Ashes from the last cleaning could still be found around the ashpit doors. Steam hissed from leaky joints and fittings. Hot water dropped down my back from the maze of steam piping overhead, no matter where I stood. Draft gages were covered with dirt, leaving the scale entirely hidden from view. Sometimes they had oil; more often they had not. Many recording instruments hadn't operated since no one knows when. And there was always trouble. Coal was bad, steam was down, men were dissatisfied and quitting.

Then I thought of a plant that I had visited just the day before. The nickel draft gages are polished faithfully every day. The glasses are clean and I can read the scale twenty feet away. The recording instruments tick off the flue-gas temperatures and CO_2 percentages every day in the year. The glands of the feed pump are well packed. The boilers are clean inside and out. The atmosphere of the boiler room is healthy and the floor looks like Sunday. I always love to visit this plant. The coal is good, the steam is always there when it is wanted, the men are happy and there is no trouble.

Two kinds of plants have been cited. The difference between them is not a matter of better equipment. The acid test of a chief engineer is that he get the most out of existing equipment. It is not a matter of labor troubles at the plant. A capable chief can handle his men. It is not so much a matter of poor coöperation from "the men upstairs." An intelligent chief will command respect and coöperation. The difference between them is a difference in the men that operate and care for them.

The boiler room reflects the character of the chief just as surely as water reflects the sky. Give me one look at the draft gages on the boilers and I will tell you the caliber of the chief engineer. Not because a polished draft gage means higher CO_2, lower flue-gas temperature or better economy, but it indicates care and pride on the part of the man in charge. It means that the details are being watched.

The man who sees that a draft gage is polished will see that a leaky blowoff valve behind the boiler is repaired. He will see that the cracks in the setting are plugged up. He will see that leaky joints in the steam line are made tight, a leaky trap is repaired. He has time to set the valves of his engines. He takes care of the plant "just as if she were his own."



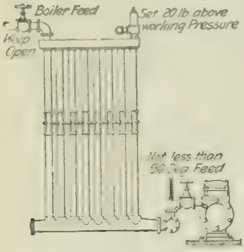
Care of Economizers

By J. F. DAGGETT*

Some Helpful Suggestions as to the Operation and Care of Economizers, Probably the Most Neglected Apparatus in the Boiler Plant

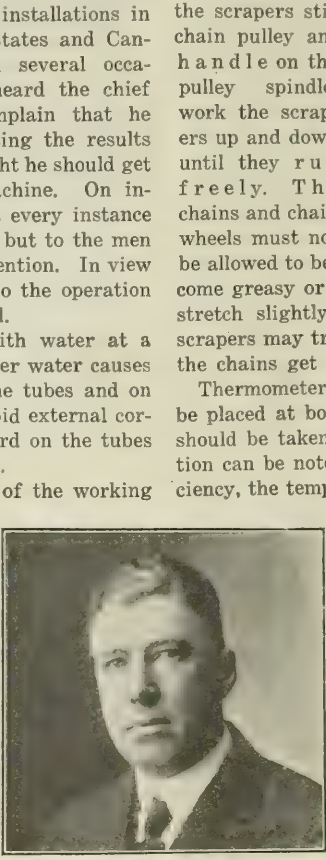
ON ACCOUNT of the coal shortage and the high cost of fuel, economizers have been installed in most steam-power plants erected in the last three years. As many of the men in charge of these will be using economizers for the first time, it may be well to go over the essential points pertaining to their operation and care.

There is probably no boiler-house adjunct that pays a better return on the investment than the economizer, and it is probably the most neglected apparatus installed. The reason why economizers are usually neglected is that they are installed in out-of-the-way places and receive attention only when something goes wrong. This neglect is not intentional, but happens principally because there is so little trouble experienced with this apparatus. I have inspected many of the installations in the United States and Canada, and on several occasions have heard the chief engineer complain that he was not getting the results that he thought he should get from the machine. On investigation, it was found that in almost every instance the trouble was due not to the machine, but to the men in charge in not giving it the proper attention. In view of the foregoing a few suggestions as to the operation and care of economizers may be helpful.



An economizer should not be fed with water at a temperature lower than 90 deg. F. Colder water causes condensation on the lower portion of the tubes and on the bottom headers, which results in rapid external corrosion. The soot also becomes baked hard on the tubes and prevents the scrapers from working.

A relief valve set at 20 lb. in excess of the working pressure on the economizers should be placed on the feed pipe between the pump and the economizer. This will take care of excessive pressure built up by the pump. The outlet valve between the economizer and the boilers should always be kept open. The furnace draft should be regulated by the main damper at the outlet end of economizer, and not by the boiler dampers. The latter should be used only in case a boiler is laid off or when the economizer is shut down. Care should be taken to prevent cold air from leaking into the main flues by making all crevices in the brickwork air-tight.

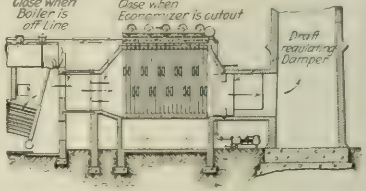


J. F. DAGGETT

The economizer should be blown off for a few minutes daily, both at the top and bottom, through the safety and blowoff valves. The tail pipe from the blowoff valve should fall evenly to the drain, thus enabling the apparatus to be emptied when necessary.

The safety valve should not be set more than 20 lb. in excess of the working boiler pressure. All valves, and especially the safety valve, should be carefully examined weekly, and all waste water delivered so that it will not drain into the soot pit, flues, or cleaning-out space.

The scrapers should be kept constantly running when the economizer is in use. The cross-shaft carrying the clutch-box should run at 55 revolutions per minute. If the scrapers stick, remove the setscrew connecting the chain pulley and the wormwheel and, by means of a handle on the pulley spindle, work the scrapers up and down until they run freely. The chains and chain wheels must not be allowed to become greasy or they will slip. After a time the chains stretch slightly and should be shortened so that the scrapers may traverse the whole length of tubes. When the chains get worn, turn them around on the pulleys.


Close when Boiler is off Line
Close when Economizer is cutout
Draft regulating Damper

Thermometers, pressure gages and pyrometers should be placed at both ends of the economizer and readings should be taken daily. In this way the internal condition can be noted; that is, if there is falling off in efficiency, the temperature of the water and gas remaining the same, it will show that the economizer needs to be cleaned, as there is some cause preventing the proper transmission of the heat of the flue gas to the water. This is due to dirt either inside or outside of the tubes.

If the feed water should contain lime, salts or other impurities, and an anti-incrustation fluid is used, it should be introduced by means of a small injecting pump into the feed pipe before entering the economizer. The vertical tubes and the bottom headers should be examined and cleaned internally at least every twelve months. Do not allow the soot chamber below the economizer to get too full. It should be cleaned out at least once a month. The space between the vertical tubes, bottom headers and side walls should also be thoroughly cleaned. Any dampness in the flues, foundation or soot chambers should be remedied on discovery.

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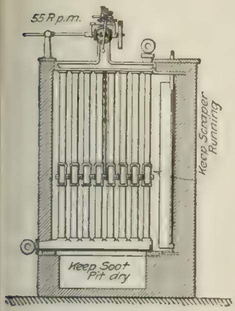
*Works Manager, Green Fuel Economizer Company.



If the water in the economizer gets too low, immediately open the bypass flue damper and close the economizer inlet damper, leaving the outlet wide open. Also open the direct boiler-feed valve and close the inlet and the outlet economizer feed valves. Remove covers from the soot-pit manholes and open all doors into the economizer chambers. Do not touch the safety valve until the tubes are cool.

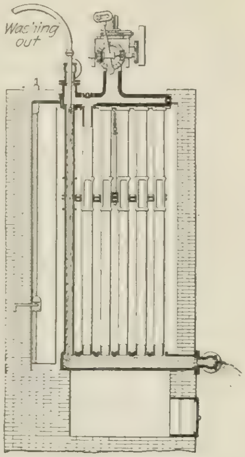
Economizers located in exposed places, when not in use, should be emptied in frosty weather.

To shut down an economizer open the bypass flue damper and close the inlet and outlet economizer dampers, also open the direct boiler-feed valve and close the inlet economizer feed valves.

When it is necessary to clean an economizer internally, all the internal caps should first be removed; then it will be possible to clean the tubes either with the hand scraper or by a water-driven turbine cleaner. The latter method is quicker and also has the advantage of the water flowing through the tubes, carrying the refuse with it.

When cleaning an economizer, be careful to open the blowoff and relief valves, also knock in several internal caps in different parts of the machine. Then open both inlet and outlet dampers, allowing the hot gases to pass through the economizer chamber and around the tubes for a period of about twenty minutes. During this time be sure to keep the scrapers operating.

If, after doing this the tubes are found to be still dirty, it will be necessary to burn them off, but this method requires a man trained for the work and it is much better to apply directly to the economizer company for a man who is familiar with the process. The foregoing covers the essential points in the operating and care of economizers. Repairs are better treated individually, as the types of economizers vary somewhat and when repairs are necessary, it is best to get a man from the manufacturers who is expert and experienced in this kind of work.



Carelessness in Refrigerating Plants

By E. W. MILLER

The author tells in a vivid way of some of the careless acts done in refrigerating plants, resulting in suffering and death to the operatives. Usually, the carelessness of one man is responsible for the suffering of many others. Leaving a coil or receiver full of cold liquid ammonia, with no opportunity to expand, suddenly breaking pipe joints and "spinning" valves shut are causes of serious accidents.

THE careless man is probably more of a menace in a refrigerating plant than in any other branch of power-plant engineering, as a large volume of ammonia gas suddenly let loose can prove more disastrous to human life than a boiler explosion. In an electric plant he is often more of a menace to himself than to others, because workmen as a general rule can take sufficient precautions to protect themselves. In the refrigerating plant, however, this is not so truly the case.

Some trouble had been experienced with the expansion valves on one of the coils in a large beef cooler in a packing-house plant. It happened to be on a very cold day and the ammonia leaving the condenser, which was of the atmospheric type and located on the roof where the wind had a good chance at it, was cold enough so that even the liquid receiver was slightly frosted.

The liquid line and the coil on which the defective expansion valve was located were pumped out, the valve cleaned out, a bit of packing being the cause of the trouble. Pumping out the liquid line of course reduced it to a low temperature and further reduced the temperature of the liquid when it was again turned into the line. The expansion valve on the coil which had been repaired was opened until all the gas and air were out, as determined by the sound in the valve. It was then shut off because the cooler at this time was below the required temperature.

For reasons best known to himself the assistant engineer who directed the repair job shut off the stop valve in the main liquid line some distance back from the expansion valve. About noon men began to load the cooler with freshly killed beef, and the temperature climbed rapidly from about 29 deg. to about 48 deg. before the temperature man knew of the loading.

A freshly loaded beef cooler is as hard to find one's way about in as is a densely foggy morning, and the temperature man groped his way through the rows of hanging beeves to the back of the room, where the expansion valves were located. There were some five or six other men in the cooler at the same time. About the time that the temperature man had reached the rear of the cooler a gasket in one of the liquid line joints near the cooler exit blew out, and the liquid in the line, expanding as in normal operation in the coils from the heat in the room, rushed out through the opening.

The leak was directly in front of the door, and it was impossible for anyone to get past it without being sprayed with the escaping liquid. The men, terror-stricken, had to back up into the rear of the cooler. The temperature man, on being informed of the accident, opened all the expansion valves, which were close together, hoping by this means to reduce the pressure in the line somewhat and thus reduce the leak. In this he was more successful than he had expected, because he was not aware that the line was shut off.

The air became insufferable, however, except near the floor, which all of them hugged as closely as possible while they yelled for help. Finally one of the men remembered where a door had been nailed up recently and all crawled along the wall until they found the door. Then getting a full breath they would hold it while they jumped up and tried to ram the door. They had to work quickly as they were winded in a few moments and breathing was impossible while standing even partly erect. Two of them finally collapsed when the other four, getting desperate, made one last attempt and finally rammed the door open. Two more collapsed just outside the door, and the other two had just enough energy left to drag out into the other room the two who had collapsed. Three of them were unable to do anything for nearly six weeks.

The accident was due to the engineer shutting off this section of the line at both ends. The cold ammonia in the line expanded to a very high pressure when the room warmed up and, as it was a solid block of liquid with no chance for relief, something had to let go—in this case the gasket. Fortunately, no one was killed, but only the resourcefulness of the men saved their lives. Liquid in the ammonia system should never be shut off so that it has no room for expansion. Always leave some outlet open for relief.

In another plant a gang of men were painting the ceiling and girders. At this time they were working directly above two 200-ton vertical machines. Trouble developed with the packing on one of the machines, and the chief decided to shut it down, pump it out and repack it. After it was stopped, he ordered one of the assistants to go out on the condensers and shut off the stop-valve in the discharge line of this machine at the condenser.

The assistant was one of those fellows who does a thing first and thinks about it later. Grabbing the stop valve, he gave it a spin that sent it shut at once. A series of reports, like those of a small gun, followed inside the power house and he hastily opened the valve again. The shock created by such manipulation of the valve broke some joints in the line, liberating ammonia. When he got back into the power house, the crew were carrying one of the painters down from the deck of one of the machines and were working over another on the floor. The painters had been unable to find their way down and finally some of them had dropped from the scaffold above the machines down on the deck when they were overcome with the fumes.

A large condenser had been shut down for repairs. On the day that work was to be started, it was pumped out thoroughly, but some other work turned up and nothing was done until the next day. In the morning the steamfitter and his helper asked for another pumping on the condenser to make sure that it was clear. The assistant engineer to whom he made his request, however, laughed at him and chided him for being too careful. The steamfitter refused to go to work on the condenser, however, until he had gained his point, and sat down and waited for the chief to appear. The assistant became peeved at this disregard of his advice and authority and, grabbing a couple of wrenches and a hammer, went out in the condenser shed to break open a joint to show the old steamfitter that he was too cautious.

Someone passing the shed heard him hammering at something and there was a sudden report and roar, as if a steam pipe had burst. The men who rushed to the scene tried to get inside the room, but the ammonia fumes were so dense that the men were blinded the moment they stuck their faces inside the door. Finally, one of them with a gas mask managed to get inside and drag the man out. He was dead.

One of the valves connecting this condenser with one of the others had leaked sufficiently to practically fill the condenser with gas up to probably full condenser pressure. The man had evidently removed all the bolts in the joint which he went to open and then hit it with a hammer, when the joint had sprung wide open. He had probably been directly in the path of the escaping fumes.

Ammonia joints should never be broken in a hurry and never without having first provided an opportunity for escape in case the fumes should become excessive. Loosen up each just a little and then gradually gently work the joint open with a chisel or other device. If then there is pressure on the joint, there is at least plenty of time to get away, and generally it can be tightened up again before the fumes become dangerous.

In another case a large triple-pipe brine cooler had frozen. After the trouble had been located, the engineer shut off the cooler both at the expansion valve and on the suction end. He then proceeded to thaw it out by blowing steam on and into it. It stopped the operation of one of the departments, and quite a number of the men came down into the engine room to find out about it. The cooler was in a small compartment by itself, and the whole crowd was inside watching the performance.

Suddenly, one of the flanges cracked and a stream of ammonia liquid shot out. It was only a few feet from the entrance to the compartment, and some of the men were nearly strangled before they got out.

The engineer was further back in the room, and the clouds of steam prevented him from noticing the leak until the gathering fumes warned him. By this time they were so strong that he was blinded before he could reach the door; probably he never would have got out if one of the oilers had not gone in with a gas mask and partly dragged him out.

The trouble in this case, the same as the one related in the beginning of this article, was due to the cooler having entirely filled with liquid when the cooler froze. Shutting it off on both ends left no room for expansion, and when the steam was turned long enough to warm up the liquid in the cooler, the pressure became so great that something had to let go.

Load Division Between Induction-Type Frequency Changer Sets

By QUENTIN GRAHAM

IN A RECENT article in *Power*, "Load Division Between Synchronous Frequency Changers Operating in Parallel" (Oct. 8 and Oct. 22, 1918), the load division between frequency changer sets of the synchronous type operating in parallel on both ends was discussed in detail. It is the purpose of this article to discuss the corresponding problem which arises when two induction-type frequency changers are operated in parallel. The term induction type as used here refers to a motor-generator set consisting of an induction motor and a synchronous generator, Fig. 1.

The problem of load division between frequency changer sets of this type is much simpler than the problem of load division between synchronous sets. In fact the problem is the same as that encountered in paralleling engine- or turbine-driven alternators.

In the article already referred to, it is shown that alternators in parallel driven by engines or other prime movers divided the energy load in accordance with the speed-load characteristics of the prime movers. That is, each prime mover delivers a certain definite amount of power at each speed, and since the speeds of the two paralleled units must be the same at all times, assuming alternators of the same number of poles, the output of each unit is determined by the speed-load curves. The same reasoning applies to alternators driven by induction motors.

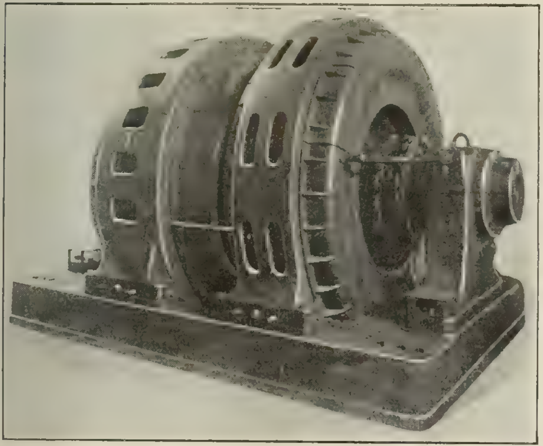


FIG. 1. INDUCTION-TYPE FREQUENCY-CHANGER SET

Each of the motors has a speed-load curve which is practically a straight line over the working range, as shown in Fig. 2. The speed curves shown here are for two motors of different capacities, and the reduction in speed, or slip, shown by each curve is 6 per cent. at the rated output of the motor. At any other slip the proportion of load carried by each machine is the same. Thus if each motor has the same speed as the other at all times, the proportion of load which each carries is fixed. Since the generators, which are driven by the motors, are in parallel the units must have the same speeds at all times. It is to be understood, of course, that if the motors have not the same numbers of poles their speeds are not the same but have a constant ratio at all times.

In order to change the proportion of energy load carried by each set, the speed-load curves must be changed. With engine-driven units the speed-load curves may be changed by means of the governor and the division of load may be controlled. With induction motors something analogous to an adjustment of the governor may be accomplished by varying the secondary resistance. With increased secondary resistance the speed curve has a greater slope so that the drop in speed for a given load must be greater. Thus if one or both of the motors of two induction-type sets have wound secondaries, so that the resistance can be varied, the division of energy load may be controlled.

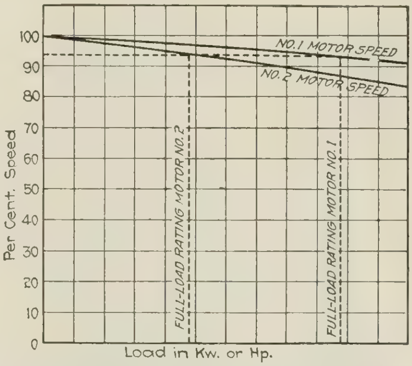


FIG. 2. CURVES SHOWING RELATION BETWEEN INDUCTION MOTOR SLIP AND LOAD

A change in the excitation of the generators has the same effect as with engine-driven machines. The power factor of each machine can be changed; one machine can be made to carry more or less of the reactive or wattless component of the load, depending upon whether its excitation is increased or decreased. Such variations in excitation have no effect whatever upon the energy component, however, since this depends entirely upon the speed curves of the motors.

In the discussion of synchronous sets it was shown that changes in excitation have a decided effect upon load division. It was also shown that by shifting the frame of one of the machines circumferentially the division of load could be changed. With an induction-type unit such a procedure has no effect whatever, since there is no fixed phase relation between the induction-motor rotor and the supply circuit. To insure satisfactory parallel operation of induction-type sets, therefore, it is necessary that the per cent. slip, or speed decrease at rated load, be the same for all motors.

Revision of A. S. M. E. Boiler Code

Part I, Section I

A REVISED edition of the 1914 Boiler Code has just been issued by the American Society of Mechanical Engineers and represents the work of the Code Committee during many meetings extending over a period of about two years. A number of changes have been made in the rules. This article will attempt to point out the changes and corrections that will be of interest to manufacturers and inspectors of boilers or others who are interested in the application of these rules as regards the construction of boilers.

REFERRING to Part I, Section I, in all formulas that are concerned with thickness of material, *t* is used to represent this value if the thickness in inches is to be used. Where the thickness is to be taken in sixteenths of an inch, *T* is used to represent the thickness. In some instances in the old Code the failure to make this distinction was very confusing.

Par. 9 has been modified to allow the use of malleable iron for cross-pipes, headers and cross-boxes for pressures up to 200 lb. per sq.in. provided the cross-section of such parts will fall within a 7 x 7-in. rectangle (see A, B, C).

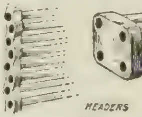
Par. 12 has been changed to indicate that cast iron may not be used for nozzles of flanges attached directly to the boiler (see D). The intent of the original Code was to the same effect, but the point was not properly brought out.

The use of cast iron for water-leg rings and door frames, in vertical fire-tube boilers, has been prohibited by a change in Par. 13 (see E).

A

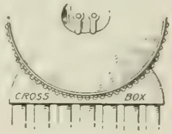
Par. 19 has been revised to show that the intermediate values for the thickness of butt straps, as given in Table I of the Code are to be determined by interpolation; strap thicknesses for plates over 1¼ in. in thickness are given. The strap thickness for plates of 1 in. thickness has been changed from ¾ to 11/16 inch.

A table giving the allowable pressures on tubes of all sizes from ½ to 5 in. diameter and with a range in thickness from 17 to 5, B.w.g., is given in connection with Par. 21. The pressures given in this table do not materially change the pressures allowed for tubes from 3 in. to 4 in. diameter in the original Code; in fact, the pressures permitted have been increased slightly for commercial sizes within this range of diameters. Radical changes in the requirements for the smaller-sized tubes have been made by the revision. In the case of tubes for fire-tube boilers, as given in Par. 22, the minimum diameter to which the table applies is made 1 in., instead of starting at zero. The last part of this paragraph has been changed so that a definite increase in pressure is allowed for each gage increase in tube thickness. The old Code allowed an unlimited increase in pressure, above 175 lb. for one gage thickness over the gages specified in the table given in this paragraph.



B

The copper content specified for firebox steel in Par. 25 has been eliminated.



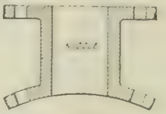
C

The range in tensile strength for firebox steel has been changed from 8000 to 10,000 lb., as given by Par. 28. A new part, Section *b*, has been added to this paragraph, which requires a minimum elongation of 24 per cent. for material of 11/16 in. thickness or less. From the wording of Section *b* of Par. 28, it appears that the modification for the elongation for thicker plates as expressed in Par. 29, should be considered in applying Section *b* of Par. 28. However, the wording of Par. 29 appears to make the modification apply only to Section *a*, of Par. 28.

In Par. 30, a definite location from which the test specimens are to be taken is given. The tension-test specimen A (see F) to be taken from the bottom of the plate and in the direction of the longitudinal axis of the ingot; except that for plates that are to be used so that the transverse axis of the plate is to lie in the circumference of the shell, this test specimen *B* shall be cut at right angles to the axis of the ingot. The bend-test specimen *C* is specified to be cut transversely from the middle of the top of the plate. Specifying this location and direction for the bend-test specimen seems to be entirely proper, if the prescribed test is one that all portions of the plate should meet. It is practically certain that if the specified sample meets the requirements, all other portions of the plate will be up to the required standard.

The quench-bend test, as previously specified in Section *b* of Par. 30, has been eliminated in the new Code.

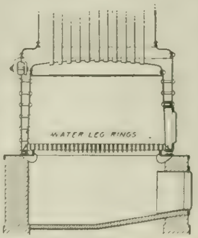
The minimum yield point of 0.6 of the tensile strength of the material, as specified in the second line of the table in Pars. 123 and 141, has been changed to 0.5 of the tensile strength of the material.



D

The manganese content for tube material, as specified in Par. 165, has been changed from a range of 0.30 to 0.50 per cent., to from 0.30 to 0.60 per cent. The flange test, as given in Par. 167, has been materially changed. The old Code made a uniform requirement calling for a flange of ⅜-in. width to be turned on tubes of all sizes and thickness. The new Code requires the flange test only for tubes 6 in. or less in diameter, and where the thickness is less than 10 per cent. of the outside diameter, and provided this thickness does not exceed No. 6 B.w.g. The width of the flange to be turned is also limited to 10 per cent. of the outside diameter of the tube, between the limits of ⅛ and ½ inch.

For the hydrostatic test on tubes required by Par. 169, a limit of 16,000 lb. per sq.in. for the fiber stress produced by the test has been prescribed. Where this limit is exceeded by the test pressure specified, a formula is given to determine what the test pressure shall be.

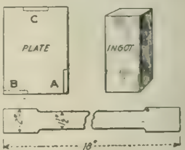


E

The requirements for workmanship, as specified in Par. 174, have been changed so as to make a distinction between the requirements for contour for tubes 3½ in. in diameter and less, and those of larger size.

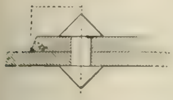
The rule for back pitch, as given in Par. 182, has been changed and is now in a more easily understood form than previously.

Par. 183, which deals with the amount of lap that is to be left on longitudinal seams, now specifies a maximum as well as a minimum limit for this dimension. The points between which the lap is to be measured are also indicated, and a limit for the angle of the bevel on the calking edge has been designated (see G).



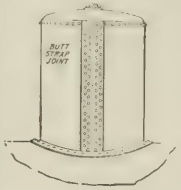
F

The addition of the words, "that required for," in the third line of Par. 184 *a*, has removed an inconsistency which existed in the previous Code. The requirements as now stated for the strength of girth seams in this paragraph are based on the required strength of the longitudinal seams instead of on their actual strength. By an addition made to Par. 186, the use of autogenous welds is permitted, provided such welds are not subject to stress and the safety of the structure does not depend on the strength of the weld.


G

An addition to Par. 187 indicates that the first portion of this paragraph, which specifies that butt-strap construction is required on the shells of drums over certain diameters, does not apply to the portion of the shell which is staybolted to the firebox, as in the case of the vertical fire-tube type of boiler.

By the addition of Section *c* to Par. 192, a requirement for the relation between the strength of the longitudinal and circumferential ligaments between the tube holes in a drum where the tubes enter the shell, is given. These requirements are the same as those given in Par. 184 in reference to the required strength of longitudinal and circumferential seams. The treatment of the strength of diagonal ligaments between tube holes in the shell of a drum has been changed; a diagram has been substituted for one of the formulas previously used in this paragraph.

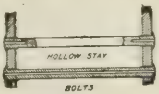


H

The wording of the first part of Par. 194, relative to domes, has been revised to definitely indicate that the longitudinal joint on a dome 24 in. or over in diameter must be of the butt-strap construction. The previous wording of this paragraph appeared to make the requirement for butt-strap construction hinge on the requirement for a pressure in excess of 100 pounds (see H).

An addition has also been made to this paragraph relative to domes, which specifies limits for the radius used on the flange of the dome.

In Par. 199 a new value for *c* has been added. This value is 150 and applies to stays screwed through the sheet or to taper-fit stays, provided they have heads not less than 1.3 times the diameter of the stays.

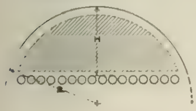


I

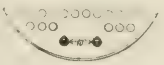
In Par. 200 a change has been made which removes the necessity for drilling the ends of stay-bolts as specified in that paragraph, provided the length of the bolts is in excess of 8 inches (see I).

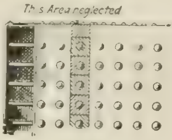
The rules in Par. 201, in regard to the staying of boiler heads, have been elaborated and made more definite.

Paragraph 203 has been made much more explicit and is now arranged to cover the spacing of every kind of brace commonly used on the flat surface of a boiler head.


J

Paragraph 212, which was a two-line paragraph in the former edition of the Code, is now over a page in length. This paragraph formerly dealt only with the question of cylindrical surfaces which required staying. In the present Code the strength of constructions similar to the outer furnace sheets of a vertical fire-tube boiler is treated, and also the strength of the wrapper sheet of a locomotive-type boiler. Both of these subjects are new. Following the above, the question of the spacing of the stays on a cylindrical surface is considered. Instead of requiring such spacing to be the same as for flat surfaces, as was the case in the former Code, an extra allowance is given for the spacing of stays on cylindrical surface. The requirements for the area on the segment of a head to be stayed, as specified in Par. 214, have been changed. In the former Code, the surface 2 in. from the tubes and 3 in. from the shell was deducted from the total area of the head to find the area to be stayed. The distance from the shell, used to find the area to be deducted under the new rules, may vary with the radius of the flange, the thickness of the head and the allowable pressure. The area that may be deducted under the new rules will generally be greater than was permitted under the former rules. The change in this paragraph, 214, has also been made to replace the first portion of former Par. 215, relating to the heads of water-tube boilers (see J).


K



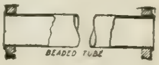
L

The rule specifying the distance apart that tubes may be spaced in a fire-tube boiler without requiring the application of stays as expressed in Par. 216, has been changed; the intent of the new wording, however, appears to be the same as before.

The formula given in Par. 217, for determining the area to be stayed on the segment of a head, has been rearranged so as to comply with the changes made in Par. 214.

An addition has been made to Par. 218 which makes the minimum distance, in the clear, between through braces placed below the tubes in the horizontal-tubular type of boiler, 10 in. This should be a welcome change to the boiler inspector and to the boiler cleaner (see K).

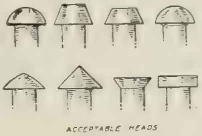
Paragraph 220, which treats of the subject of computing the stresses in stays, has been materially lengthened. Conditions which arise in practice, the treatment of which may be confusing to the designer and the boiler inspector, are fully explained (see L).



M

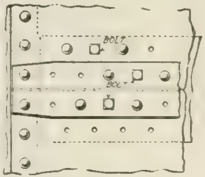
Two lines have been added to Table V, which gives the maximum allowable stress for stays and stay-bolts. One of these additions indicates that for hollow stay-bolts of less than 20 diameters in length, an addition in the allowable stress of 500 lb. per sq.in. is permitted over that allowed for similar bolts that are solid or of the flexible type. The other addition to this table provides for the allowable stress for steel through stays that are over 1½ in. in diameter

To determine the design of braces and brace conditions, Par. 223 has been divided into eight divisions, and the whole subject appears to have been covered. The former wording of this paragraph was not clear, and the changes made will no doubt be welcomed by the designer and the inspector.



N

A limit for a minimum vertical distance between the rows of tubes, where a staggered arrangement is used, has been given for use in applying the requirements of Par. 234. The subject of plain cylindrical furnaces, as treated in Par. 239, has been changed considerably. The formulas used have remained unchanged. Unstayed furnaces from 12 to 18 in. in diameter have been provided for; if not over 4½ diameters in length, they are considered as furnaces, if of greater length they are considered as flues. It is now arranged that for furnaces of more than 18 in. up to and including 38 in. in diameter, if over six diameters in length, the length is to be assumed as being of six diameters for the purpose of calculating the maximum allowable safe working pressure. This removes a serious criticism of the former rules in regard to long furnaces. It has been shown by experiment that six diameters is the critical length, and that beyond this point length is not a factor to be considered in determining the strength of a furnace.



O

Paragraph 245 has been changed with regard to the pressure that is to be allowed on malleable-iron headers. This change was evidently made to obtain agreement with the change that was made in Par. 9.

The test requirements for malleable-iron headers have been inserted in Par. 246; this paragraph has also been arranged to cover the subject matter of old Par. 247.

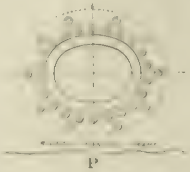
A new Par. 247 has been inserted, which provides for the testing to destruction of a boiler or boiler parts where it is impossible to calculate the strength with a reasonable degree of certainty. This is an important provision and should prove useful.

The wording of Par. 250 has been changed so as to require the beading of both ends of the tubes in fire-tube boilers (see M).

Paragraph 251 has been modified to permit the welding of tube ends in water tube boilers.

Fig. 70, on page 71, has been added. This illustrates the form and dimensions of acceptable rivet heads (see N).

It is specified in Par. 254, that after the rivet holes have been drilled and the burrs removed, the reassembling of the parts shall be accomplished by the use of barrel pins and tack bolts.


P

A requirement that has been added to Par. 256 makes it necessary to drive a rivet each side of each tack bolt used before the tack bolt may be removed (see O).

A specification of the angle to which the calking edges of plates, butt straps and heads are to be beveled, is inserted in Par. 257. A similar requirement relating to the calking edges at the longitudinal seams has already been mentioned in connection with the changes made in Par. 183.

An addition made to Par. 258 makes it necessary to reinforce a handhole opening where the longest dimension of such opening is more than 6 inches.

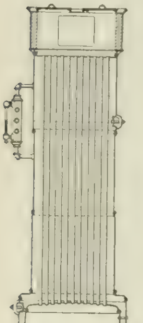
The treatment of the requirements for reinforcing manhole openings, as given in Pars. 260 and 261, has been changed. Par. 260 now indicates what the requirements are that must be met as regards the reinforcing rings, and Par. 261 indicates what the requirements are that must be met in regard to the strength of rivets (see P).

The wording of Par. 266, which deals with the requirements for the application of handhole openings has been changed. The requirements given in the old Code do not apply to boilers of 24 in. diameter or less; two openings are specified as a minimum for these small boilers (see Q).

A change in Par. 268 requires that for all boilers to be operated at pressures of over 100 lb., any outlet over 3-in. pipe size must be arranged with a flanged connection.

SAFETY VALVES

The limit for the size of safety valves where one may be used alone, as specified in Par. 269, has been changed from 3-in. diameter to a limit expressed in relieving capacity, this limit being 2000 lb. of steam per hour. The limit for the maximum lift of safety valves, as previously specified in Par. 272, has been removed. Any lift up to one that will give a discharge up to the full discharge capacity of the opening at the base may be used, provided the valve is so constructed as to open gradually, so as to not lift the water in the boiler, and further provided that no detrimental shocks are produced through the operation of the valve. The limits for diameters of safety valves, as previously provided in this paragraph, have also been removed.


Q

The requirements as regards the markings to be placed on the body of a safety valve, as covered by Par. 273 have been considerably changed.

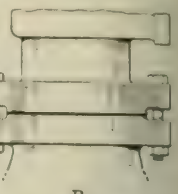
The safety-valve relieving capacity that must be supplied for a boiler, as required by Par. 274, has been changed as regards boilers operating at pressures of 100 lb. or less. For such boilers a basis of 3 lb. of steam per square foot of boiler-heating surface per hour, is used.

Requirements for discharge pipes used in connection with safety valves have been added to Par. 279.

The requirements for the lifting gear to be supplied with safety valves, as given in Par. 282, have been modified. Without steam on the valve, the lifting gear must be capable of lifting the valve $\frac{1}{16}$ in. from its seat instead of one-tenth of the valve diameter, as previously required.

A requirement has been inserted in Par. 283, that the seat of a safety valve must be fastened to the body of the valve so as to prevent the seat lifting with the valve. It is specified in Par. 284 that a safety valve and its spring must be so constructed that the valve may lift from its seat one-tenth of the diameter of the valve seat before there is any interference.

A change in Par. 286 permits the use of flat-faced flanges for safety valves for pressures as high as 250 lb. Raised faces must be used on the flanges of safety valves for pressures over 250 pounds (see R).

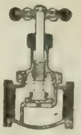

R

A change in Par. 288 requires that at least 75 per cent. of the total safety-valve relieving capacity that must be supplied for a boiler shall be placed directly on the boiler, when the relieving capacity of safety valves that are attached to the superheater are to be considered in connection with the total relieving capacity required. An addition to Par. 290 provides for the attachment of internal collecting pipes or splash plates for safety-valve outlets; certain restrictions in regard to the design of such devices are given.

WATER AND STEAM GAGES

An addition to Par. 291 specifies how the lowest permissible water level for the various types of boilers may be determined.

The absolute restrictions as to the use of automatic water gages, given in Par. 292 of the previous Code, have been removed. Such devices are permitted, if constructed in accord with specifications for automatic water gages, given in the appendix of the Code.


S

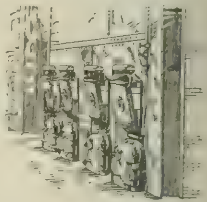
A provision has been added to Par. 296, to permit the proper installation of valves in steam-gage lines where the gages are located at a distance from the boilers.

Par. 299 has been increased materially. The added matter treats of the use of cast-iron and steel fittings and clears up much of the ambiguity that existed in the previous edition of the Code in regard to the this subject.

Blowoff requirements, as specified in Par. 311, have been changed so that the requirements specified for stationary boilers do not apply to traction or portable boilers.

Par. 314 has been changed by removing the requirements in regard to the use of globe valves on feed lines and placing them in Par. 317 (see S).

A method of attaching the supporting brackets on traction or portable boilers that differs from similar requirements for boilers of other types is given in Par. 325.

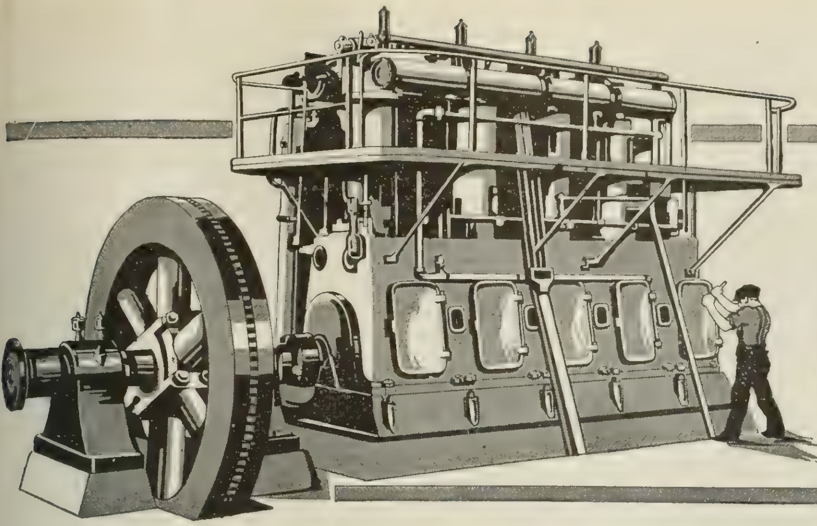

T

The requirement for inward opening doors, or that the doors must be supplied with substantial latching devices, in the case of water-tube boilers, is now made to apply to stoker-fired boilers of this type as well as to those fired by hand, according to changes that have been made in Par. 328 (see T).

The stamping of boilers, as provided for in Par. 332, has been materially changed. The new paragraph on this subject takes up a space of practically two pages. It should be read carefully by the inspector and manufacturer.

(Revisions in Part I, Section II, Heating and Hot-Water-Supply Boilers; Part II, Existing Installations, and the Appendix will be given in the next issue of POWER, *Feb. 18.)*

The new giant tri-plane type flying machine nearly completed by Giovanni Caproni, to be driven by Liberty motors, develops 21,000 hp. It is of six-ton capacity and built to carry 29 passengers. The plane will be luxuriously finished. The interior will be modeled after a limousine, with upholstered seats and glass-inclosed passenger compartment. It will be heated by electricity and the motors will be equipped with muffler.



Talks on DIESEL Engines

by L. H. Morrison

VI—At this meeting the talk turns to piston rings and piston construction. Egan explains the reason for scoring of cylinders and sticking of pistons.

ON THURSDAY NIGHT, when the men gathered for their regular hour of discussion, they found Egan waiting. Kelly was still engaged on his job of erecting the second-hand Diesels, and the importance he inwardly felt was reflected to some extent in his manner.

"Chief," he inquired as he rolled a cigarette, "how bad can a piston be scored before it's got to be replaced?"

J. R. smiled as he asked Kelly the reason for the question.

"Well, I've found the pistons on those Diesels in pretty bad shape. They are cut right above the pins. I've measured them and they're about a thirty-second inch out of round. What I want to know is—does that mean new pistons?"

"Kelly," said Egan, "when a piston is as bad as that, you may as well give up all hope of good results until you get a new piston. There seems to be a good bit of haziness over the allowable piston wear. Some engineers think that new rings will stop all compression leaks, no matter how badly the piston is scored.

"I've interested myself in this question, and I've never found any piston delivering the goods when the clearance between cylinder and piston was over one-hundredth of an inch. I might even go stronger and say that seven-thousandths of an inch is the maximum clearance that should be allowed."

"Don't you think rings will help?" asked Woods.

"Why, yes, rings will help in any case. If we had no rings, we would lose our compression even if we had only one-thousandth clearance. The point I am trying to make is that an engineer shouldn't expect new rings to remedy a worn piston."

"I've been seeing a lot of advertising of the two-piece ring," continued Woods. "Will that work in a Diesel?"

"I've no doubt that a two-piece ring is leak-proof in a gasoline engine, where the compression is below 100 lb. per sq.in., but it won't stand up in a Diesel. You must remember that here our compression is around 550 lb., and the two pieces of the ring will wedge together. This isn't theory—I've proved it to my own satisfaction by making up a set and trying them out."

"That's funny," exclaimed Kelly. "In those Americans I'm manhandling, the grooves are wide and take two rings per groove."

"Probably some bright engineer's experiment," J. R. answered drily. "But," he continued, "I'd suggest you measure the width of the groove and the width of the two rings. You'll find that the groove has worn considerably wider than the rings. This play of rings in the groove allows the charge to blow past, and the wear is excessive with two rings per groove."

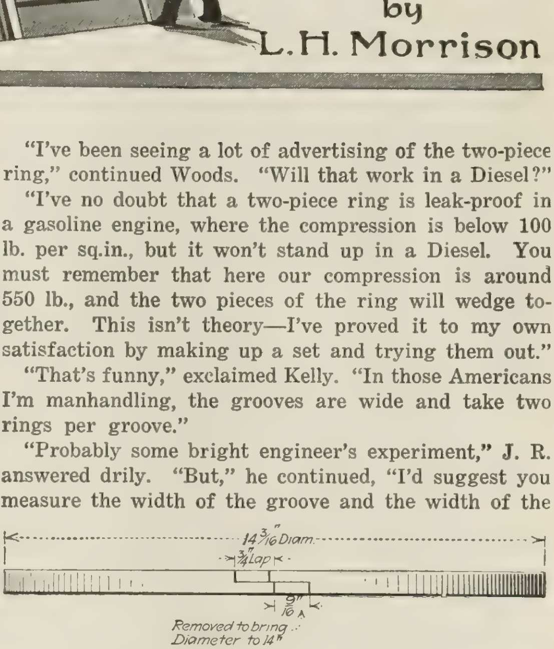


FIG. 1. FORM OF JOINT IN PISTON RING

"Do you think a ring should be turned up eccentric before cutting?" asked Woods.

"Such a ring is designed correctly and from a theoretical standpoint is better than any other kind. However, in practice, there seems to be no advantage, and it is harder to make. In having our rings made where the piston is between 12 and 18 in. in diameter, I always order them $\frac{3}{16}$ in. larger in diameter than the cylinder bore. When machined up, there is then about $\frac{9}{16}$ in. to be cut out to let the piston enter the cylinder. In making the lap, our practice has always been to cut the rings as in Fig. 1, giving about $\frac{3}{4}$ in. lap, which insures a good seal at this point."

In next article the chief explains the causes of piston distortion and fracture and methods of overcoming such troubles

"J. R., what clearance do you allow between the groove and the sides of the ring?" inquired Kelly.

"A lot of engineers have new rings fit loose in the grooves. But I'd advise just enough clearance for a working fit—not more than a thousandth of an inch on each side. Then there won't be much chance for tar deposits. Another thing to remember is that it's poor policy to round off the edges of a new ring, for that causes rapid wear. The best plan is to smooth up the burrs, if there are any, but make the edges perfectly true. Usually the machine shop sends the rings with a fairly good finish, but even if the surface is fairly smooth, it's a good idea to go over the rings with fine emery cloth. For the smoother the rings, the longer they will last and the less lubricating oil required."

"J. R.," observed one of the men, "I noticed that one of our old engines has two pistons with four rings apiece, while the third piston has five. Why is that?"

"That engine, when it came from the factory, had four rings per piston," said Egan. "We found that a small amount of wear allowed the charge to leak by, and so we put a fifth ring on the middle piston, since the leakage was greatest around it. This was not done on the two outside cylinders because their pistons had thin walls—quite likely a case of slipped cores. You see, there is a thickening of the piston walls behind each ring groove; but the slipping of the core didn't leave enough metal for a groove. Another thing, you'll notice we added on all the pistons three oil grooves below the center of the piston. Originally, no oil grooves were used, but we found they helped the lubrication of the cylinder and reduced piston leakage.

"In regard to the number of rings," continued the chief, "both our new 500-hp. engines have six rings per piston, but I don't think six absolutely necessary. In fact, two of the pistons are short a ring apiece until we can get new ones.

"Now, boys, when it comes to pistons, you're getting on dangerous ground. Steam engineers and critics of oil engines always harp on piston failures. But if you investigate, you'll probably find the objection based on some failure that occurred years ago, on one of the first Diesel engines. In recent years you run across few actual cases of piston seizing. When they do occur, you will usually find the trouble due to poor installation or lack of attention. This company has twenty-five Diesels of four or five makes, and I know of but one case of piston seizing. It happened right here, when Kelly first came to work for me, and it wasn't the fault of the engine, either. I had ordered a new piston and when it came it was too snug a fit; but the day engineer forced it into the cylinder by using a sledge. When the engine warmed up, of course the piston stuck."

As he finished speaking, he unfolded several sheets that he took from an inside pocket and spread them out on the table, disclosing a series of sketches like those shown in Figs. 2 to 5.

"These sketches will give you men an idea of some of the different types of pistons you may run against," the chief went on. "Fig. 2 is a section of the piston generally used on the first Diesel engines. If you are familiar with gas engines, you will agree that this is a typical gas-engine piston, the only change being the ribs to strengthen the head. This is the same piston that we have in our old American Diesel engines."

"Why did engine builders quit using this piston?" inquired Woods. "It looks simple and easy to make."

"The reason is the answer to the majority of complaints as to pistons sticking and wrecking engines. If you men will look into this matter you will see that the piston walls have very thin sections. The head is well supported by the ribs and doesn't show any more cracks than does any other type. However, the heat generated in the cylinder is partly absorbed by the piston pin, and the pin expands lengthwise. The bosses supporting the pins are fairly heavy and resist any distortion. But as the bosses join onto rather thin sections of the wall, and these thin portions have no support, the piston is bent until its cross-section has the form of an ellipse. The long diameter of the ellipse is greater than the original diameter of the piston, and both the piston and the cylinder are bound to be scored. When the piston cools off and returns to its former shape, the ends of the ellipse will appear flat."

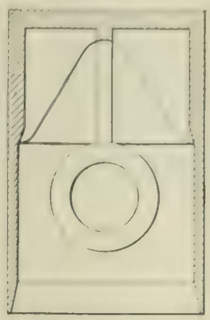


FIG 2

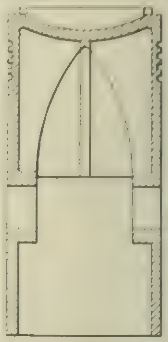


FIG 3

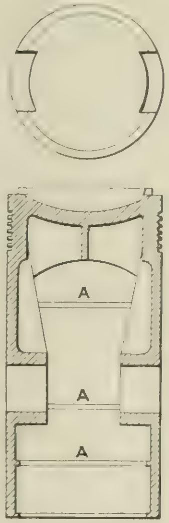


FIG 4

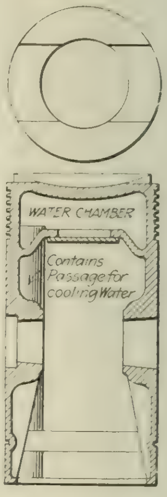


FIG. 5

FIGS. 2 TO 5. FORMS OF PISTONS FOR OIL ENGINES

"Well, chief, what do you do when such scoring does happen?" asked one of the others.

"Just what we have done twice at this plant—pull out the piston and smooth the scored places to a good surface with emery paper.

"However," Egan continued, "ordinarily there is no excuse for this scoring. If the operator will allow the cooling water to circulate through the cylinder jacket for fifteen to twenty minutes after shutting down, the engine will give up all the contained heat to the water, and no great amount of heat will be absorbed by the pin. I want to emphasize the fact that the pin expansion occurs when the engine is shut down and not while it is running.

"In Fig. 3 the head is made concave to better withstand the expansion. Also notice that the ribs are all carried well down toward the middle of the piston, which, of course, makes the walls more rigid. While the ribs help to hold the piston to shape, their real value lies in the strength they give to the head. This is an improvement over the one in Fig. 2, but it can't be termed a modern design.

"Fig. 4 shows how the designer has practically eliminated all danger of piston distortion. The head is slightly concave and has short ribs to give additional support. The most attractive feature is the ribs *A* around the interior piston wall. These ribs give great strength to the wall, and there should be no distortion because of temperature conditions. I know that in five of our engines fitted with this type of piston we have had no trouble with pistons sticking.

"In Fig. 5 we have a piston built along similar lines. However, this one is intended to be water-cooled, and a water chamber is provided in the head, as you can see."

Difference in Water Levels in Boilers

By F. R. McLean*

In connection with the differences of water levels occurring in multiple-drum boilers, which have been discussed at some length in recent issues, a brief outline of many observations and experiments made over a period of several years may be of interest.

The boilers at one station consisted of seventy-two 650-hp. three-drum boilers equipped with superheaters, and at another station there were thirty-two boilers of similar design and size but without superheaters. In both instances they were set in pairs having a common or party wall and the drums nearest the party wall were called inside drums. Then came the middle drums and adjacent to the outside walls the outside drums.

When the boilers were installed, water columns were fitted to the outside drums. Samples of water were collected from these columns and tested to regulate the blowing off. It was found after much experimenting that these samples did not represent conditions in the middle or in the inside drums. The salinity used as a measure of the concentration was found to remain uniformly low over extended intervals, whereas the salinities of the middle and inside drums would rise rapidly almost regardless of the amount of blowing off to values that were often seven or eight times the concentration shown in the outside drum.

Thousands of samples were taken from all three drums of the boilers, and the outside drum always contained water with the lowest salinity. It was proved conclusively that these variations were caused by different rates of evaporation, the outside drum adjacent to the relatively cool outside wall evaporating much less water than the middle or inside drum close to the party wall.

Internally, the middle and inside sections of the boilers —that is, the drums and tubes—would contain much more mud and scale than the outside sections. The feed-water connections were arranged to distribute equal amounts of water to each drum, but as the middle and inside evaporated more water than the outside, they pulled water steadily from the outside through the mud-drum, thus stirring up the mud and carrying it into the middle and inside sections. This emphasized the need for frequent inspection of the internal feed lines, drum-head check and stop valves to see that they were in no way obstructed. When the individual feed line to one drum was found obstructed, that section would show high concentration of salts, mud and scale. By the installation of orifices of slightly different sizes in the individual feed lines, a reasonably uniform concentration of deposits was obtained in all three drums.

Gage-glasses were installed on all three drums of a number of boilers, and readings were made under different conditions of operation. Some of the boilers were hand-fired, and many of the stoker-fired units were equipped with underfeed stokers. On a hand-fired boiler a U-tube consisting of two water columns and gage-glasses, was connected into the steam space of the outside and the inside drum to determine any differences in pressure that might exist. Under all normal conditions of operation the inside drum pressure exceeded that of the outside drum by from 1 in. to 4 in. of water. Firing under the inside drum was stopped until the fire was nearly dead on that side before the excess pressure changed over to the outside drum. These differences in pressure existed, although equalization was permitted through the superheater and safety-valve cross-over pipes. When the boiler was actively steaming, the differences in water levels were not great unless the fire became very uneven. The doors were numbered and fired alternately with the doors of the adjoining boiler.

In starting the boiler up from a cold or banked condition, alarming differences of water level were observed. For instance, with the water at half a glass in all three drums and the pressure 25 lb., the water in the outside drum would start down and the water in the inside drum start up as the pressure increased until it was below the bottom in one case and above the top in the other. This again was the result of the relatively cold outside wall and hot party wall, causing a great variation in the densities of the mixed steam and water on the two sides. The superheater was drained at all times. When the boiler cut in on the line automatically, the water levels would readjust themselves, showing only comparatively slight differences.

It was clearly demonstrated that unequal levels, unequal heat concentration and unequal accumulation of mud and scale were for the most part inherent in the boilers, owing to the setting in pairs. No appreciable difference in levels between the front and rear ends of any one drum was discovered.

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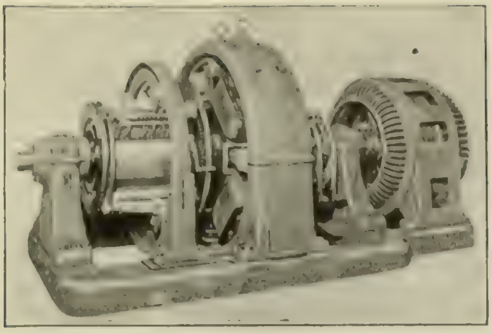


Characteristics of Carbon Brushes for Electrical Machinery

By WARREN C. KALB

Carrying capacities, contact drop, coefficient of friction, abrasiveness and hardness of carbon brushes are defined and the methods of determining those characteristics are explained

IN THE application of carbon brushes to any given service there are certain physical characteristics that must be taken into consideration. These are determined by the manufacturer of the brushes through exhaustive laboratory and service tests and are made available to the user by means of tables, curves and descriptive data. It will be interesting to discuss some of the more important of these characteristics.

Carrying capacity is the load-current density in amperes per square inch of cross-section that a brush can carry without serious heating. In determining the carrying capacity of a given grade of brush, it is necessary to consider all the factors affecting the temperature of that brush in operation. This includes, in addition to the specific resistance of the brush, its commutating properties, coefficient of friction and heat conductivity.

The carrying capacity indicates the permissible current density in the brush on a machine of average design under normal operating conditions. Higher current densities can be permitted for short periods of overload, unless the conditions affecting the brush operation are unusually severe. The following table gives some idea of the carrying capacities of the different types of carbon brushes. These will be described in a subsequent article.

Carbon-graphite	30 to 40 amp per sq in.
Graphite-carbon	35 to 50 amp. per sq in.
Graphite	55 to 70 amp. per sq.in.
Electrographitic	30 to 65 amp. per sq in.
Metal-graphite	50 to 125 amp per sq in for commutators
	70 to 150 amp per sq in. for slip rings
Carbon-gauze	80 to 100 amp per sq in
Metal-gauze	Up to 200 amp. per sq.in. on slip rings
Copper-leaf	Up to 200 amp. per sq in on slip rings

On motors subject to intermittent service, such as crane motors, vehicle motors and railway motors, it is possible to use a considerably higher rating than that normally given. This is because the brush has opportunity to cool off between periods of use.

When considering carrying capacity in the selection of a brush for any given service, the load-current density should be figured in the brushes at the full load on the machine and the grade selected which has a carrying capacity equal to or above the current density estimated. If the machine is to be operated for long periods at a considerable overload, it is well to make the selection as regards carrying capacity more liberal than for a machine that is to be operated at or near normal load.

The resistance at the contact between a brush and the commutator or slip ring on which it bears varies approximately in inverse ratio to the current density. In other words, the voltage drop across the brush contact is approximately uniform over the working range of current densities, and for this reason this characteristic is expressed as contact drop rather than as contact resistance. The contact drop as usually given by manufacturers of brushes is the sum of the drop across the positive and negative brushes. The drop across the contact of one brush is approximately one-half the figure given for the positive and negative.

Fig. 1 shows the general method used in determining contact drop. The brushes to be tested bear on a copper ring or short-circuited commutator *R* which is driven by an adjustable-speed motor so that the contact drop can be tested at any desired peripheral speed. These brushes are connected through an ammeter *A* to an external source of power which may be either of variable voltage or controlled by a rheostat in series with the brushes *B*. Leads from a voltmeter *V* are placed on the brushes as near their contact surface as possible, and in this way the voltage drop across the contacts of positive and negative brushes combined is determined. This is the form in which this information is usually published. If it is desired to give the contact drop of either positive or negative brush alone, one of the voltmeter leads must be placed in contact with the ring on which the brushes bear.

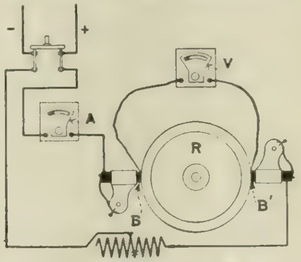


FIG. 1. METHOD OF MEASURING BRUSH CONTACT DROP

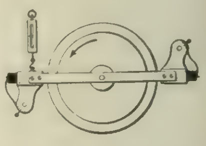


FIG. 2. METHOD OF MEASURING COEFFICIENT OF FRICTION

Contact drop has more influence than any other on the commutating properties of a brush. For this reason it is desirable that it should be as high as possible consistent with other characteristics on any brush which is to be used on commutating service except on the lower ranges of voltage. On machines with a terminal voltage of less than 100 it becomes desirable to keep the contact drop of the brush as low as the commutating characteristics of the machine will permit, otherwise the heat loss at the brush contact may become a considerable percentage of the total losses in the machine.

Most brushes used on industrial and power apparatus of 110 volts and above will have a contact drop of 1.5 to slightly over 2 volts. Brushes for automobile-starting motors, where high torque rather than commutation is the determining factor, will have a contact drop as low as 0.2 volt. This, of course, can be secured only in a metallic or composition brush.

Brushes for electroplating generators, battery-charging generators, vehicle motors and other types of low-voltage machines require contact drop between the ranges previously mentioned. On slip-ring service high resistance at the brush face is of no advantage, and for this reason the contact drop should be kept as low as possible consistent with the other characteristics required in the brush.

The coefficient of friction is the ratio between the tangential pull exerted by the commutator or slip ring on which the brush bears and the radial pressure applied at the brush face. This characteristic determines the peripheral speed at which it is permissible to operate a brush without chattering or undue heating. It is customary among brush manufacturers in describing their grades to give the maximum peripheral speed to which each grade is adapted rather than the coefficient of friction. Information so given is more readily used in applying the brush to service than the abstract figure for coefficient of friction.

In measuring coefficient of friction a machine is used similar to that on which contact-drop tests are made. In fact, the same apparatus is frequently used for both tests. In making the coefficient of friction tests, however, it is necessary that the brush-holders should be supported on a movable yoke which is capable of oscillation about the same axis as that of the slip ring or commutator on which the brushes bear. A spring balance attached to this yoke at any point and held in a position at right angles to it will give the tangential pull at the point of attachment due to the friction of the brushes on the ring as indicated in Fig. 2. Multiplying this figure by the ratio of the radius arm at the point of attaching the spring balance to the radius of the ring will give the tangential pull at the brush faces. This figure divided by the total pressure applied to all the brushes bearing on the ring gives the coefficient of friction.

Another type of apparatus has been used for both contact drop and coefficient of friction test in which the brushes, instead of bearing on the periphery of a ring, bear on the flat surface of a disk. This type possesses certain advantages as well as disadvantages over the ring type, one of the principal advantages being the accuracy with which the surface can be ground, insuring uniform condition at the start of every test.

Brush manufacturers are at times unwilling to admit that any grades of their products possess abrasive properties. This is due to a prejudice that has grown up against abrasive brushes and the belief that the possession of any abrasive property whatever is likely to result in excessive commutator wear. This is an unfortunate condition, as there are very often circumstances where the possession of a moderate degree of abrasiveness is a decided advantage in a brush. This is particularly true on commutators, the mica of which has not been undercut, making it necessary for the brush to cut away the mica as the surface of the copper is burned down under severe operating conditions.

Where the mica of the commutator is undercut, it is not necessary to have any abrasive property in the brush, except under very severe conditions of operation, and even then only enough abrasive or polishing action is required to overcome whatever burning occurs on the commutator surface and keep it in a nicely polished condition.

Brushes are manufactured which are absolutely nonabrasive as near as such a condition can exist. Other grades are manufactured which possess a polishing action and still others which possess various degrees of abrasive action. A few grades are made with such a degree of abrasiveness as to result in serious cutting action on the commutator. These grades are not to be recommended except under the most extreme conditions. Unfortunately, there is no reliable test for this most important brush characteristic, nor is there any unit by which it may be described. For this reason the best that a manufacturer can do is to describe this characteristic of his brushes in general terms. Hardness is a term that is frequently confused with abrasiveness, but as a matter of fact is an entirely different characteristic. It relates to the compactness of the mass of the brush as a whole, whereas abrasiveness relates to the cutting action given a brush due to the presence of more or less gritty particles in the brush composition.

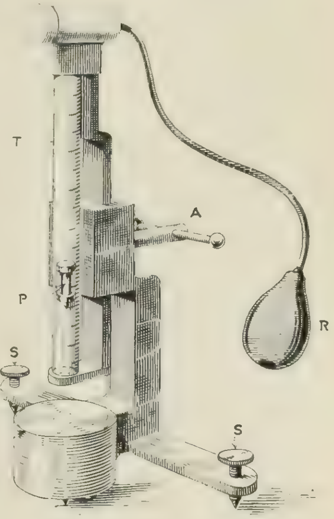


FIG. 3. SCLEROSCOPE

Hardness has less influence on the operation of brushes than is generally supposed, but where other conditions are equal the harder brush will usually have longer life. On the other hand, the softer brush will be quieter where there is a tendency for vibration or chattering. While a very hard brush may possess absolutely no abrasive property, the harder of two grades will usually polish a commutator or ring better than the softer, provided the abrasive characteristics of both grades are similar.

It is customary to define the hardness of a brush by means of the scleroscope test. This is a small instrument in which a steel weight is allowed to fall from a constant height upon the article whose hardness is to be measured. The rebound along a graduated scale is recorded as a measure of the hardness of the article. The following table gives a comparison between the scleroscope reading and the degree of hardness as relating to brush material:

Scleroscope	Degree
0 to 15	Very soft
16 to 30	Soft
31 to 45	Medium
46 to 60	Hard
61 and over	Very hard

The scleroscope consists primarily of a glass tube *T* about 10 in. long mounted on a substantial frame and adjustable in height by means of the lever *A* with relation to the base of the frame *B*, Fig. 3. Before making a test the heavy base plate *B* is carefully leveled by means of the adjusting screws *S*, which insures the tube *T* being vertical. A sample of the material to be tested is then placed on the base *B* and the bottom of the tube brought down firmly upon it.

Within the tube is a small loose-fitting weight or piston *P* having a diamond point. The diamond point is used to insure uniformity in shape, inasmuch as even the hardest steel would gradually change shape under continued use and affect the reading of the instrument. By means of the bulb *R* this piston is drawn to the top of the tube, where it is held by a latch until released by another pressure of the bulb. When released, it drops freely upon the sample being tested and rebounds, the height of the rebound depending on the hardness of the material on which it is dropped. At the back of the tube is a graduated scale by means of which the rebound is measured, and the reading of this is recorded as the scleroscope indication of hardness.

This reading does not represent any definite unit, but is merely an arbitrary scale. It is a fairly accurate indication of the relative hardness of materials of like nature that cannot be used to judge the relative hardness of dissimilar materials. The figures given in the table are intended to convey to the man experienced with brushes some idea of what the scleroscope readings indicate. That is, a brush that he would class as being soft would probably fall within the range of 16 to 30 on scleroscope readings, a brush which he would class as medium in the range 30 to 45, one that is hard in the range 46 to 60, and so on. Specific resistance, mechanical strength, and density, both real and apparent, are other characteristics which are studied by the brush manufacturer, but which are of minor importance to the user and will not be discussed at this point.

(*The next article will discuss the composition and construction of the various types of brushes and their application.*)

Lend to the End!

American patriotism fights for America in peace as well as in war. We talk America, think America and frequently dream America. Our armies fought and won the war in France. We fought on this side with our labors and dollars. Now we are to fight again—in the new day of peace, to insure permanent peace and prosperity. Again it is a question of patriotism, with the same munition—dollars.

Secretary of the Treasury Carter Glass estimates the probable amount of the new Victory Loan at $5,000,000,000. Victory Bonds will be offered for popular subscription within a few weeks. They will offer to all of us the last time in our lifetime, probably, to strike decisively for the United States in the fight to uplift a world to our democratic standards.

Only the shirker will seriously ask why another loan is necessary. The answer is plain. America started out to finish a big job—the biggest, undoubtedly, she or any other nation ever attempted to accomplish. The armistice brought a cessation of hostilities, but it did not pay war's bills, the billions required to provision, clothe and care for a huge army.

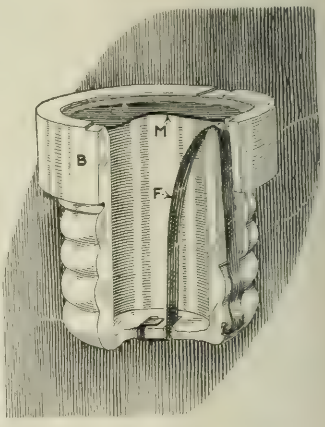
We still have an army of one million men in France to be fed and otherwise maintained for a considerable period of time. Prior to this war such an army would have staggered the national imagination, but world emergencies dictate that we must maintain it at present. We assure ourselves of emergency capital through support of the Victory Loan. This forthcoming war bond issue is our method of finishing up the world's biggest job. Americans never quit; they finish strong, spurred by the patriotism peculiar to all of us.

Citizens of a republic which sent two million men oversea to fight, want to bring them back as soon as possible. They want to give a chance to men who left their work to develop their resources again in a debt-free country. Nobody will oppose the idea of teaching the maimed self-supporting trades. We all want the wounded to receive the best possible care until the last man leaves an army hospital.

Accomplishing these things is constructive fighting, in which patriotic Americans everywhere can participate. Putting over the Victory Loan will be the finest sort of fighting with which to finish the "biggest job."

Refillable Plug Fuse

Most readers of *Power* no doubt are familiar with the various types of refillable cartridge fuses and multiple types of plug and cartridge fuses on the market, which have been described in this paper from time to time. Here is another one of the latest of the refillable-fuse family, a refillable plug fuse, manufactured by A. F. Daum, Pittsburgh, Penn. As shown in the figure, the only metal part to this fuse is the fuse metal. The metal thread, base plug and part of the cap used in the old type of nonrefillable fuse have been eliminated. There are only three parts to this fuse: A porcelain base *B;* a mica cap *M*, which is pressed into the base, but which can be removed and replaced to fill the fuse; and the fuse metal *F*. The fuse metal strip is placed in the plug as indicated in the figure, and when the fuse is screwed into the cutout socket, contact is made between the fuse metal and the socket at the side and bottom. These fuses are made in sizes from 3 to 30 amperes for 125-volt circuits, and the refillable fuse strips are put up 100 in a box, in any amperage up to 30.



SECTIONAL VIEW OF FUSE

Because of the inherent shortcomings of raw lignite as fuel, one can safely say that it will never be used to any great extent in its raw state. The fact that it contains 30 per cent. of water alone would prevent its use elsewhere than in the immediate vicinity of the mine.

Combustion and Boiler Settings—II*

BY A. D. WILLIAMS

The effect produced on the combustion reactions and the circulation of the gases by the chilling due to contact with water-cooled surfaces is described.

WHEN coal or other commercial solid combustible is burned directly in the firebox, it is difficult and in some cases impossible to obtain a temperature around 1600 deg. C., though the theoretical combustion temperature of a good grade of coal in an athermal inclosure is about 2050 deg. C. This temperature limitation arises from the fact that it is practically impossible to force sufficient air for complete combustion through the incandescent bed of fuel; in other words, the bed of burning fuel acts as a producer of combustible gases which in turn must be burned by an additional air supply.

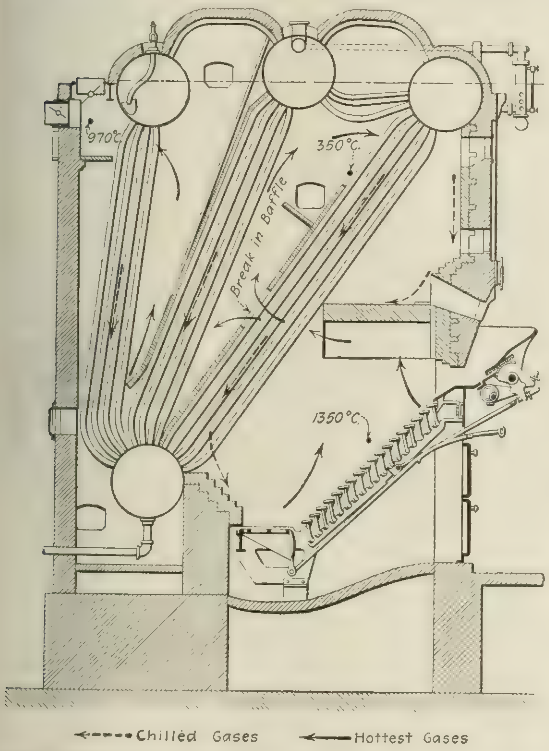


FIG. 1. FLOW OF GASES IN BOILER WITH BROKEN BAFFLE

A very interesting series of tests on "Combustion in the Fuel Bed of Hand-Fired Furnaces" (Bureau of Mines, Technical Paper 137) has been made by Kreisinger, Ovitz and Augustine. One of the features of this paper that attracted the writer's attention was the fact that the mass of air per unit of combustible as computed from the analysis of the gases in the upper layers of the fuel bed was, in all cases, less than the mass of air per unit of combustible as measured by an orifice meter introduced into the ashpit. The quantity of air forced into the ashpit was also less than the theoretical air supply required for the fuel.

In endeavoring to obtain an explanation of this difference, it was found that the computed combustion temperatures derived from the heat capacity of the gases in the fuel bed agreed very closely with the observed temperatures. This would appear to indicate that a part of the air supply, instead of passing up through the fuel, passed up the walls of the firebox. Another thing the writer recalled that pointed to such a conclusion was that he had noticed on several occasions that a fire seemed to burn faster close to the wall than it did in the center of the grate and that he had frequently noticed clinkers along the walls and fused to them when the central portion of the fuel bed was free from clinkers. This last would seem to indicate a sort of air-blast or oxidizing-zone effect close to the walls, strong enough to solidify the viscous ashes.

Another indication of the possibility of the air passing up between the wall and the fuel bed lies in the fact that the CO_2 curve in a number of the tests had two peaks—one a high peak with low CO, then a steady decrease in CO_2 with an increase in CO, this valley being followed by an increase in CO_2 (and a decrease in CO) to a low peak, then another drop in CO_2. The last drop in CO_2 showed in only a few cases, and may be an error, as it is very slight.

The following tabulation of the results with a 12-inch fuel bed summarizes the combustion results obtained:

	Pittsburgh Coal 7 Tests			Anthracite Coal 7 Tests			Coke 7 Tests		
	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max
Carbon in ash, per cent. of total carbon	7 98	3 95	17 90	10 76	2 96	24 80	7.32	3 80	9 55
Carbon burned, per cent. of total carbon	92.02	82.10	96.05	89.24	75.20	97.04	92.68	90.45	96 20
Per cent. of carbon burned to CO_2	17.00	11.00	25.00	16.95	7.90	31.50	22.00	14.90	29 00
Per cent. of carbon burned to CO	76.00	65.00	85.00	82.53	68.00	91.50	77.70	71.00	84 90
Per cent. of carbon burned to CH_4, etc	4 00	1 00	10 00	0 52	0 30	1 00	0 30	0 10	0 60
Pressure in ash pit, inches of water		0 13	1 33		0 20	2 36		0 05	1 67
Pounds of coal per sq.ft., per hour	....	21.00	131.00	....	20.00	99.50	....	15.00	118.60
Pounds of air per pound of fuel		4 10	6 10		5 70	7 50		6 10	7 30
Pounds of air per pound of combustible		5 00	8 20		7 30	10 70		8 10	10 60
Pounds of air per pound of combustible from gases		5 20	7 20		5 90	6 60		6 60	7 60

The weight of air required to burn one pound of combustible will vary from 11.5 to 15 lb. and have a volume at ordinary temperatures of from 144 to 187 cu.ft., but the amount of air that can be forced up through the fuel bed is much less. The specific gravity of coal will average about 1.20, and a cubic foot of coal as fired will weigh from 40 to 50 lb. From this it will be seen that the volume of the voids will be between 33 and 45 per cent. of the mass and this will give the proportion of the fuel-bed area through which the air must be forced. The temperature of the fuel bed and of the gases leaving it will be about 1400 deg. C., and the gases will have an impressed velocity. The limit of ashpit pressure is reached when the ascending volume of

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air forced through the fuel is sufficient to keep it floating. Such an intense draft pressure, however, would tend to carry unburnt fuel away from the grate.

When the burning gases leave the fuel bed, they have an ascensional velocity due to their temperature alone of between 30 and 80 ft. per sec. and are at least 1000 deg. C. hotter than the heating surface of the boiler. As a result the ascending stream of hot gas will be much smaller than the area of the pass and the firebox, the remainder of this area being occupied by cooler eddies of gases chilled by their contact with the heating surface of the boiler and the walls of the settings.

An interesting illustration of the way gas may flow through a setting was shown on page 709 of *Power* Nov. 17, 1914. Mr. Smith, however, has the arrows indicating the course of the gases pointing wrong. The corrected figure is shown in Fig. 1. The hot gases from the fire rise straight up to the coking arch. Below this arch they are forced to flow horizontally to the end of the arch, where their velocity carries them through the bank of tubes and the hole in the baffle. In fact, it is probable that the failure of the baffle at this point was due to the continual impinging upon it of the hot gases. The current of chilled gas flowing down around the tubes of the boiler would also tend to force the hot gases flowing out from below the arch against the baffle. After passing through the break in the baffle, a portion of the hot gases will tend to rise into the upper portion of the first and second passes, while the remainder will be carried down by the current of cooler gases flowing down the second bank of tubes and will pass under the second baffle and then will immediately rise to the outlet, passing up the space between the second baffle and the third bank of tubes, then crossing the tube bank near the top, under the rear drum.

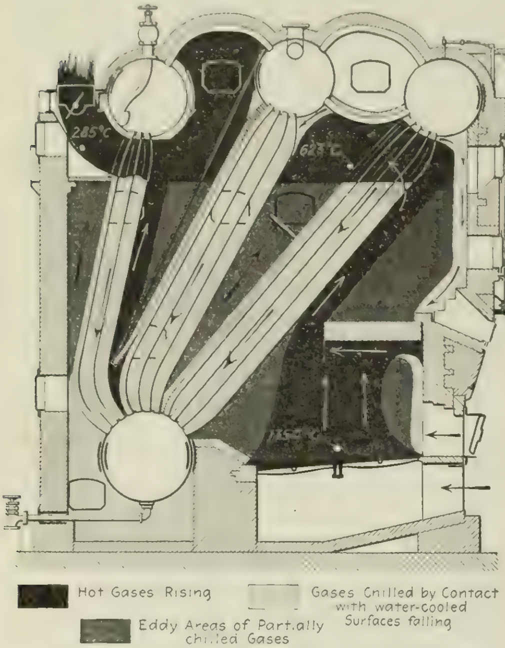

285°C
625°C
Hot Gases Rising
Gases Chilled by Contact with water-cooled Surfaces falling
Eddy Areas of Partially chilled Gases

FIG. 2. FLOW OF GASES IN BOILER WITH TIGHT BAFFLES

The explanation of this action is very simple. Any-one who has sat by a window on a cold day knows that the air chilled by contact with the window drops to the floor, and that the velocity of the air current is appreciable, although the difference in temperature between the inside of the room and the outside of the building is comparatively small, say from 20 to 40 deg. C. The same phenomenon, except that the current of air rises, may be witnessed in the vicinity of any radiator in a steam-heated building. The hot-air furnace installed in many homes depends upon convection currents for its action. If currents can be established at such low temperature heads, similar currents will certainly be established where temperature differences of several hundreds of degrees exist.

A phenomenon similar to the deflection of the current of heated gases flowing through the broken baffle by cooler downward currents can be set up by using an electric fan to break up and distribute the current of hot air rising from a radiator. The mere fact that a certain amount of gas is being drawn off at one point of the setting and a corresponding quantity of gas or air admitted at another part of the setting will not affect the local convection currents any more than the drawing off and admission of air into a room affects the current of cold air at the windows and of the heated air at the radiators.

Gases Do Not Flow Uniformly in Passages

Unfortunately, we have all been hypnotized by the idea that any current of gas passing through a series of inclosures sweeps uniformly through the full cross-section of all the passages, entirely forgetful of the fact that in gases, by reason of their high coefficient of expansion due to temperature changes, great variations of density occur. At a temperature of 1638 deg. C. a cubic meter of air weighs 0.171 kg., while at 0 deg. C. the same volume of air will weigh 1.293 kg., or 7.5 times as much. One thing that has tended to obscure the great difference in density that occurs in gases is that most engineering works consider only the weight of gases passing through a boiler, disregarding the fact that a unit weight of gas in the firebox will occupy approximately three times the volume it does when it reaches the smoke-flue connection. The hottest gases will tend to float above the cooler gases. Naturally, convection currents and conduction will tend to equalize the extreme temperature differences, if the supply of heated gases is not maintained, but equalization in this manner will be comparatively slow.

Fig. 2 shows the type of boiler with the broken baffle, but baffled according to the builder's catalog. The heated gases rising from the fuel bed impinge upon the arch where the direction of flow changes to horizontal. These gases when they reach the end of the arch will have a certain velocity of flow which will carry them beyond the end of the arch, possibly a portion of them into and through the first bank of tubes, before they start to rise again. The upper part of the first and second passes acts as an inverted pocket into which the hottest gases flow, the section under the front drum being much hotter than that under the second drum. The tube banks act as refrigerating surface for the gases and heating surface for the water.

The current of hot gases in front of the first bank of tubes is at least 700 deg. C. hotter than the tubes.

Their ascensional velocity, due to temperature, is sufficient to carry them the height of the setting in a small fraction of a second. A part of the gases will be chilled below the ignition temperature and below the temperature which would permit them to float over the top of the first baffle. These gases will circulate down in the spaces between the tubes, depositing soot on them, until they reach the back of the firebox, where they will absorb heat and tend to rise again.

DISSOCIATION OF CO DEPOSITS SOOT

The gases in the top of the second pass will have a temperature in excess of 600 deg. C., which is about 350 deg. C. hotter than the second bank of tubes, a temperature sufficiently low to permit 75 per cent. of the CO present to dissociate into CO_2, with an accompanying deposit of soot. The refrigerating surface of the second bank of tubes will chill these gases still further so that they will tend to drop into the lower part of the setting where a portion of them will pass under the second baffle. This portion of the gases will be hot enough to float up to the top of the third pass after mixing with some of the chilled gases that have flowed down the third bank of tubes. Some of the gas will be carried downward by the cooling action of the third bank of tubes, but the temperature difference between the water-cooled refrigerating surface and the gases is not very great at this point and the hottest portion of these gases will tend to rise farther into the smoke flue.

A number of attempts have been made to distribute the draft loss between the ashpit and the stack damper on a percentage basis between the different passes. All of these apparently are based upon the static pressure. In the boiler shown in Fig. 2 there are three vertical columns of gases. These columns exert a pressure against the top of the setting proportional to their vertical height and their average temperature, in the same manner as the gases in a chimney. As the gases in the first pass are lighter than those in the second pass they exert more pressure and therefore tend to force the gases in the second pass down and under the second baffle. In the third pass this uplift tends to accelerate the movement of the gases to the smoke flue. The greater the height of the setting, the greater the upward pressure. These pressures will naturally affect the reading of any draft gage attached to the boiler. The dynamic pressure due to velocity of flow may have an additive or subtractive effect on the reading of the draft gage, depending upon the location of the connections to the setting.

In connection with baffles designed, ostensibly, to increase the velocity of flow of the off gases, the following table gives the volumes of air supply and the resulting off gases from an exceptionally good grade of coal having a very low ash content:

	Volume at 0 Deg. C. and 14.7 lb. Pressure	
Air Supply, Per Cent.	Air Supply in Cu Ft per Lb. Coal	Off Gases in Cu Ft per Lb. Coal
100	139	145
110	153	159
120	168	174
140	195	201
150	209	215
175	244	250
200	278	284

As the composition of the coal varies, these volumes will vary. The coal consumption per hour per boiler horsepower will vary from two pounds up, and the total amount of coal burned on a grate will depend on the size of the boiler and the amount it is forced above its nominal rating. As large sizes are the most interesting, consider an 875-hp. Stirling-type boiler operated at several loads. The total volume inside the setting is about 5100 cu.ft., and about 30 per cent. of this space will be occupied by tubes, etc., so that the net volume will be about 3570 cu.ft. A boiler of this size should operate on a coal consumption of about 2.5 lb. per hp.-hr. with 20 per cent. excess air. The gases of combustion will have the following volume:

	Volume of Waste Gases Cu.Ft. per Sec.	
	120 per Cent. Air Supply	140 per Cent. Air Supply
Normal rating	106	123
150 per cent. of rating	159	185
200 per cent. of rating	212	246
300 per cent. of rating	318	369

The average temperature of the gases within the setting will be about 800 deg. C., and the average minimum and maximum gas volumes will be 417 and 1455 cu.ft., from which the average time of the gas inside the setting will be 8.56 sec. for the minimum amount of gas and 2.46 sec. for the maximum amount of gas. This gives a temperature drop of from 117 deg. to 407 deg. C. per sec. The distance from the grate to the smoke-flue outlet is about 60 ft., which gives an apparent velocity of flow ranging from 7 to 24.5 ft. per second.

UPWARD PRESSURE OF GASES AGAINST THE COMBUSTION ARCH

Assuming that the combustion arch is about 6 ft. above the grate and that the gases leave the fuel at a temperature of 1400 deg. C., they will have an upward pressure against the arch slightly less than 0.10 in. of water and their velocity will be about 42 ft. per sec. At 200 per cent. of rating the volume of gases rising from the fuel bed will be about 212 cu.ft. per second, which at 1400 deg. C. will have a volume of 1300 cu.ft. The firebox of the boiler has a width of 15 ft. and the arch will be about 12 ft. deep from the front wall, giving an area of 180 sq.ft. On reaching this arch, the gases lose their vertical velocity and turn horizontally. The horizontal velocity of the gases flowing out at the end of the arch will be about 15.25 ft. per sec., and the mean velocity will be about 10.20 ft. per sec. As soon as they pass beyond the end of the arch, the hot gases will have an ascensional component due to their density of zero at the end of the arch, but increasing so that their rise will be on an arc of a parabola, unless interfered with by other forces. In the boiler setting these other forces are a current of colder gases descending among the tubes and the tubes themselves, while a portion of the gases flowing out from under the arch will penetrate the colder layer of gases and possibly reach the baffle in back of the tubes. This action will occur intermittently according as the current of hot or cold gas is stronger in its surges. Naturally, these sudden changes in the temperature of the gases at the baffle will cause cracks and ultimately failure of the baffle, as shown in Mr. Smith's article previously mentioned. When this occurs, the hot gases will pass through the break as indicated in Fig. 1.

At 226 lb. pressure, absolute, the steam temperature is 200 deg. C. The temperature of the outside of the iron tube should not exceed 220 deg. C., allowing a liberal drop between the wet surface and the emulsion of steam and water, and assuming that the tube is free from both scale and soot. The temperature in the firebox is around 1400 deg. C., and it has been customary to assume that the curve representing the drop in temperature from the fire to the smoke-flue outlet is a regular logarithmic curve, but this curve is based on assumptions which violate the simplest principles of elementary physics. The difference of 1200 deg. C. between the hot gases and the water tube is nearly five times the temperature difference between that of the room you work in and that of liquid hydrogen, —259 deg. C. The refrigerating effect of the cold tube on the hot gases is almost comparable to dipping a red-hot bar of steel in liquid hydrogen.

The ignition temperature of the gases varies between 350 and 800 deg. C. and any portion of the unburnt gases coming in close contact with the tubes will be chilled below the ignition point. In the case of CO this may result in its decomposition, forming carbon and CO_2, which is an endothermic reaction releasing 38.8 calories per molecular volume of CO_2 formed, and depositing soot on the tubes. Another source of soot lies in the hydrocarbons. The high firebox temperature has a tendency to break these up, forming soot, CO and hydrogen. The luminosity of the flame in the firebox is due to the heating of the soot to incandescence, and unless this floating carbon is burned in a properly designed combustion chamber a considerable portion of it will be carried to and deposited on the tubes.

Combustion, like all chemical reactions, follows the law of mass action and the laws of chemical equilibrium. The velocity of the reaction is affected by the temperature of the reacting masses and the mixing of the combustibles and the comburent and by the dilution with inert gas. The velocity of the reaction increases very rapidly with the temperature. For example, a mixture of hydrogen and oxygen at 200 deg. C. will require months to combine while at 2200 deg. C. the explosion wave indicates that combination occurs in one ten-millionth of a second.

Increase of pressure increases the velocity of the reaction. This factor, while important in internal-combustion motors, does not amount to very much at the slight differences of pressure that exist in furnace fireboxes used in industrial heating. Dilution with inert gases slows down the reaction velocity by reason of the increase of the mass. The mixing has a considerable effect on the velocity of the reaction, as may be readily verified by observing the flame of a bunsen burner while altering the air supply. The slower the reaction velocity the longer the flame and the greater the distance the gases travel in burning. The temperature will be lower with a long flame than it will be with a short flame.

In a boiler it is absolutely necessary that combustion should be completed before the water-cooled surfaces are reached, as complete combustion will result in the practical elimination of the soot trouble, with a resultant increase in the efficiency of the heating surface. Most boilers and settings, however, are so designed that the incandescent gases are shot up against a refrigerating surface before combustion can be completed, the combustion arches and the baffling being so arranged that this refrigeration will be promoted, instead of combustion.

The Electrical Study Course—Three-Wire Systems from Two Generators

Describes how a three-wire system can be developed from two two-wire systems and goes on to show how the currents distribute among the wires for various conditions of loading.

IN THE preceding lesson it was shown that in a three-wire system three sources of voltage are available, two of which have the same value, and the third being equal to the sum of the other two. The instance given was of a 120- to 240-volt system, which are the approximate values used almost universally for such service. It is, however, entirely feasible to employ exactly the same type of distribution for any other set of voltages, higher or lower, that might be required in special cases, and whatever follows in regard to the 120- to 240-volt system is equally applicable to them.

To bring out clearly the underlying principle of the three-wire system, let us first give our attention to two two-wire systems furnishing current to lamps, as indicated in Fig. 1. Let us assume that we have two generators G_1 and G_2, each supplying 120 volts and each furnishing current to twelve 500-watt lamps, making the load on each 12 × 500 = 6000 watts or $\frac{6000}{120} = 50$ amperes when all the lamps are turned on.

The direction of the currents through the mains *A*, *X*, *Y* and *B* is that indicated by the arrow heads. For convenience the currents are designated I_A, I_X, I_Y and I_B respectively.

Let us now suppose that the points *a* and *b* are joined. This may be done without causing any disturbance in the systems since they are entirely separate. Although *a* is negative while *b* is positive, a voltmeter connected between them would show no voltage to exist and consequently there is no objection to joining them. We will further assume that the two wires *X* and *Y* joining *a* to *c* and *b* to *d* respectively, are supplanted by a single wire *N* as in Fig. 2. The current in this wire will be the sum of the currents in *X* and *Y*. Referring to Fig. 1, we find that the current in each is 50 amperes, but that the current in *X* is from *c* toward *a*, whereas that in *Y* is from *b* to *d*. The resultant current is therefore zero, since one current is positive and the other negative; that is, no current flowing in *N*.

An arrangement such as that of Fig. 2 is, as has already been stated, known as a three-wire system. There are other methods of providing the three sources of voltage required besides that of using two generators in series; they will be presented further on. For the present we will not consider the other methods because the theory of the three-wire system is independent of the apparatus that is used to provide the voltages.

Since the current in N is zero, it would appear that the neutral could be dispensed with. This is, however, true only when the load is balanced; that is, when there are just as many lamps connected between A and N as there are between B and N or, to put it more accurately, when the loads are such that the current in A has exactly the same value as that in B.

To show what happens when the loads are not the same, let us go back to Fig. 1 and assume that three of the lamps between A and X are turned off, leaving only nine in service between these mains as in Fig. 3. The current in A and X then is $\frac{9 \times 500}{120} = 37.5$ amperes, whereas that in Y and B remains at 50 amperes as before. These conditions would also hold if the system were connected as in Fig. 2, and we should have that $I_A = 37.5$ amperes, $I_B = 50$ amperes, and that I_N is equal to the difference of the currents I_X and I_Y of Fig. 3. The former of these is known to be 37.5 amperes, flowing from c to a, whereas the latter is 50 amperes, flowing in the opposite direction: namely, from b to d. That is, we have 50 amperes attempting to flow through the wire N in one direction while 37.5 amperes attempt to flow through it in the reverse direction. The consequence is that the current actually flowing will be the difference between the two, namely, $50 - 37.5 = 12.5$ amperes, whose direction will be that of the larger current, that is, I_Y, and will therefore be from b to d as in Fig. 4. If, on the other hand, the load between N and B is made smaller than that between A and N, we would find I_X to be greater than I_Y and the current through N to be from c to a.

The following deductions are to be made from the foregoing: The currents in the outside wires A and B are dependent upon the loads connected between A and N, and N and B, respectively. The currents in A and B attempt to flow through N in opposite directions, consequently we must subtract one from the other to obtain the value of the current in the neutral.

The extreme case is that in which all the lamps on one side are turned off while all those on the other are burning. Thus, let us suppose that the lamps between N and B have been turned off. Then $I_B = 0$ while I_A remains 50 amperes, and I_N will be equal to $I_A - I_B = 50 - 0 = 50$ amperes. That is, when the system is loaded on one side only, the current through the neutral has the same value as that through the outside wire to which the load is connected. This is the maximum value which the current in the neutral can have; as lamps are lighted on the unloaded side the current in the neutral is decreased, until when the loads are balanced no current flows through it.

We may go a step further than in Figs. 2 and 4 by using a single line for the two wires x and y, as is illustrated in Fig. 5, in which the arrows indicate the direction of flow of the currents as before. The manner in which these currents are then distributed in the three conductors, under various conditions of loading, is illustrated graphically in Figs. 7 to 12. The mains are indicated by large pipes which are connected to-

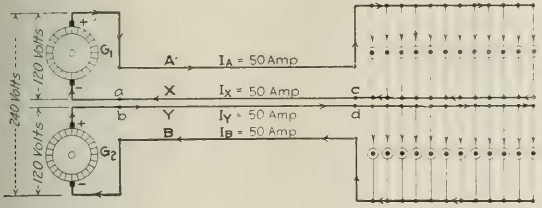


FIG. 1

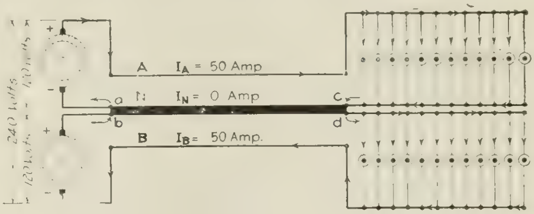


FIG. 2

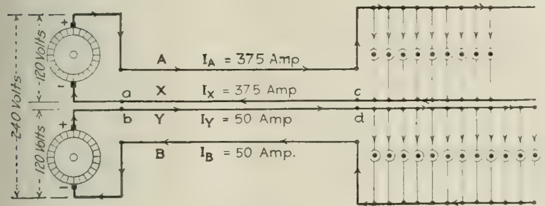


FIG. 3

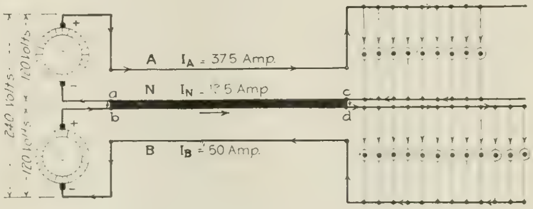


FIG. 4

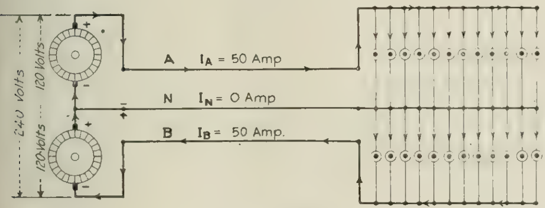


FIG. 5

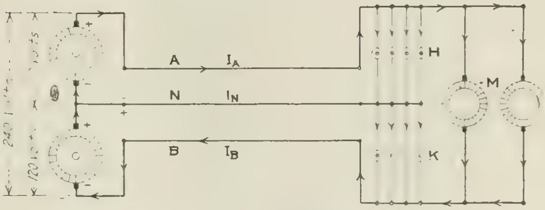


FIG. 6

FIGS. 1 TO 6. SHOWS HOW A THREE-WIRE SYSTEM CAN BE EVOLVED FROM TWO TWO-WIRE SYSTEMS gether by smaller pipes *L* which represent the lamps. The direction of the currents is indicated by the arrows. Currents flowing away from the reader are represented by the black sections and those flowing toward the observer by the hatched ones. The magnitude of the current is indicated by the amount of the circle that is occupied by the section. Where no sectioning appears, it means that there is no current flowing in the conductor.

So far we have considered only loads connected between *A* and *N* or *N* and *B*, that is, across 120 volts. There is, however, no objection to connecting loads directly from *A* to *B*—that is, across 240 volts—as for example the motors *M* shown in Fig. 6. In fact, that is one of the very valuable features of the system. We may use the 240-volt supply for the operation of motors or other large loads, and the 120-volt supplies for the lamps. We thus combine the advantages of a higher voltage for motors with that of a lower one for lamps. The current taken by a load connected to the outside wires has no effect whatever on the current in the neutral. Thus, if all the lamps connected to the system of Fig. 6 were turned off and only the motor load remained on the service, the current in the outside lines *A* and *B* would be that required by the load, while that in the neutral *N* would be zero. This is evident, since there is no connection between the motors and the neutral. Should lights be turned on while the motors are in operation, the currents required by them would divide among the three wires exactly as if there were no motor load, and the motor currents in the outside wires would therefore be increased by the currents required by the lights, while the current in the neutral would be the difference between these lamp currents, which is of course the same as the difference between the outside line currents. Thus, if the motor load *M* were 20 amperes, the lamp load between *A* and *N* (namely, *H*) where 15 amperes and that between *N* and *B* (that is, *K*) were 12 amperes, we would have as the currents in the three lines, $I_A = 20 + 15 = 35$ amperes, $I_B = 20 + 12 = 32$ amperes, and $I_N = 15 - 12 = 3$ amperes; or, if we chose to use the outside line current, $I_N = 35 - 32 = 3$ amperes.

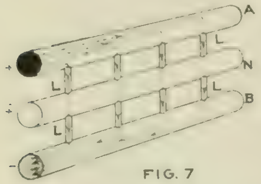


FIG. 7

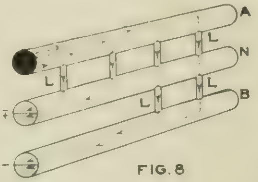


FIG. 8

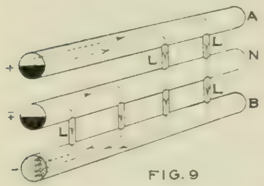


FIG. 9

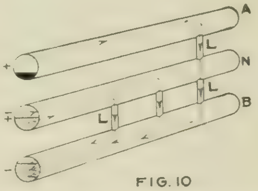


FIG. 10

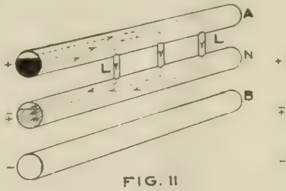


FIG. 11

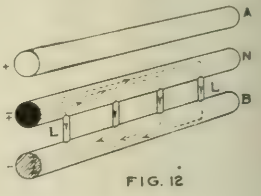


FIG. 12

FIGS. 7 TO 12 SHOWS THE DISTRIBUTION OF THE CURRENT IN A THREE-WIRE SYSTEM

The problem of the preceding lesson was to find the drop in voltage and the power loss in a line of rubber-covered wire 150 ft. long that supplies current at 125 volts to fifty 100-watt lamps and twenty ⅛-hp. motors, if the size of the wire used is that required by the Underwriters' rulings. The first thing to do is to determine the total current that the line is required to carry, upon which the size of wire necessary is looked up in the table of capacities published by the Underwriters and given in the last lesson. The resistance of that size wire is then determined by consulting a wire table and the resistance per foot as found is multiplied by the number of feet of line. Finally, the drop and loss are computed from the resistance and the current. To get the total current we find the watts (power) required by the lamps and by the motors, and divide by the voltage of the service. The lamps require $50 \times 100 = 5000$ watts. Since the capacity of the motors is given in horsepower, we must multiply it by 746 to obtain the output in watts; for the twenty motors we would have, power output $= 20 \times \frac{1}{8} \times 746 = 1865$ watts. The power input would be somewhat larger than this. If we assume the motors to have an efficiency of 70 per cent. we would have $0.70 \times$ input $=$ output, from which we obtain input $= \frac{\text{output}}{0.7} = \frac{1865}{0.7} = 2664$ watts. The total load is therefore $5000 + 2664 = 7664$ watts, and the current is $\frac{7664}{125} = 61$ amperes. This would call for a No. 4 wire, the resistance of which is 0.248 ohm per thousand feet. Since the line is 150 ft. long and there are two conductors, the total length of wire is $2 \times 150 = 300$ ft. and the resistance is $\frac{0.248}{1000} \times 300 = 0.0744$ ohm. The voltage drop is the current times the resistance, or $61 \times 0.0744 = 4.5$ volts, and the line loss is the current squared times the resistance; that is, $(61)^2 \times 0.0744 = 277$ watts.

Let Fig. 6 represent a 110-220-volt three-wire system suplying current to the lamp load *H* and *K* and to the motor load *M*. Assume that load *H* consists of eighty 50-watt and thirty 100-watt lamps; that the load *K* consists of seventy 50-watt and fifty 100-watt lamps; and that the motor load *M* is composed of one ½-hp. and one 2-hp. motor, both of which are operating at 75 per cent. of full load rating, and assume that the average efficiencies of the motors is 70 per cent. Determine the values of the currents in the mains *A*, *B* and *N* under these conditions.

Moisture in the coal fed to a furnace is a direct cause of loss of heat. It is converted into steam and so carries away the latent heat it has absorbed; also, it is superheated to the temperature of the flue gases and so carries off additional heat due to superheating.

Special Investigations on Power Supply

SECRETARY LANE of the Interior Department has sent to Congress requests for two appropriations for special investigations and report on the power supply. One of these is a request for an appropriation of $50,000 for a survey of the power resources all over the United States. This proposed appropriation is embodied in the Sundry Civil Bill, hearings on which are now being held before the subcommittee of the House Committee on Appropriations. If approved, the work would be done by the Geological Survey. The other request is for an appropriation of $200,000 for a report on the power supply for the industrial region of the northern Atlantic seaboard, extending in general from Boston to Washington. If approved this work would be done by the Geological Survey and the Bureau of Mines in coöperation. The request for the $200,000 appropriation has been approved by the Secretary of the Treasury, and has been forwarded to Swagar Sherley, chairman of the House Committee on Appropriations.

A greatly increased demand for energy will follow the resumption of industry under the operation of normal economic laws and in the face of international competition. If the country is to reap the full benefit of this returning wave of activity, it must be prepared to furnish industry and transportation with an adequate, dependable and economical power supply. Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets.

In a letter to Mr. Sherley, explaining the necessity for the appropriation just mentioned, Secretary Lane says:

I am today sending to the Secretary of the Treasury a supplemental estimate of an appropriation of $200,000 to be expended in the fiscal year 1920 for a special investigation and report on the power supply for the industrial region of the north Atlantic seaboard extending in general from Boston to Washington.

I respectfully urge that your committee consider this estimate favorably because I believe the investigation will form the basis for a constructive national policy of the highest economic and industrial significance. The country is now passing through a period of transition, which, I firmly believe, will soon be followed by one of industrial activity and expansion. The enormous development of war industries had created an almost insatiable demand for power, a demand that was overreaching the available supply with such rapidity that, had hostilities continued, it is certain that we should now be facing an extreme power shortage. Happily, such a crisis was averted by the signing of the armistice and the ensuing curtailment in the demand for war materials has carried us past immediate danger of a power famine in the industrial districts of the Northeast.

This subsidence in the demand for power will, I think, not be long continued. In a few months and especially in the regions mentioned, I anticipate a greatly increased demand for energy, for which present facilities are inadequate. This demand will follow the resumption of industry under the operation of normal economic laws and in the face of international competition, factors that have been largely inoperative during the war. If the country is to reap the full benefit of this returning wave of activity it must be prepared to furnish industry and transportation with an adequate, dependable and economical power supply. Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets, maintaining at the same time the American standard of wages and living. That there is opportunity for a system of power supply far more economical and efficient than that now existing in the areas under discussion can not be doubted. It has for its central idea the development of a plan for the generation and distribution of power on a scale far more comprehensive than now exists in this territory and the more efficient use of the power in industry and in transportation.

This result will be accomplished through the interconnection of existing power centers by means of a trunk-line transmission system of high efficiency. Into this trunk line, energy will be fed from hydro-electric plants and steam power stations located at tidewater and near the coal mines. From it will be taken the power required for each principal industrial center and for the electrification of trunk-line railroads and of such branch lines as may be located in metropolitan districts.

Such a comprehensive system of power supply, making use as it would of unutilized or undeveloped water power and of fuel now wasted at the mines, will result in large savings in coal. A very large amount of coal now consumed by steam-power plants can be replaced by the development of water power. Fuel power can be developed near the mines and the wasteful transportation of coal by railroad to that extent avoided. I am reliably informed that as a conservative estimate 50 per cent. of the fuel now used by the railroads in this territory can be saved through the operation of trains by electricity instead of by steam locomotives, because of the much higher efficiency that can be obtained in the economical central station in comparison with the wasteful steam locomotive.

The transmission of this energy as electricity instead of the hauling of coal by rail will relieve the railroads of this territory of an enormous freight burden, thereby making available transportation for the hauling of other commodities. This is a matter of far-reaching importance. Not only would the railroads in the immediate territory be relieved of hauling the coal for their own locomotives, but other railroads supplying them with coal would be relieved proportionately. This easing of the present strain on trackage and equipment would result automatically in an increase in transportation facilities, the necessity for which the country is now facing.

Such a comprehensive system of power supply will give opportunity for the more continuous use of existing power plants through the operation of the diversity factor; that is, power for which there is no demand at a certain time in one locality can be transmitted to another locality needing power at the moment. Spare units in one power center can then be used to assist other power centers in case of emergency or breakdown. A large amount of spare capacity can thus be brought into service and the capital already invested in existing power stations thus made more productive.

That such economies and efficiencies can readily be obtained has been amply demonstrated by the repeated application of these principles to local situations. It is my conviction that they can be applied regionally with even greater success. My purpose in asking for the appropriation is to make possible the investigation necessary to their practical application in this particular region. The report to follow would present a definite plan for development and estimate accurately the savings to be effected.

I am urging the earliest possible action, because I believe such a plan should be formulated at once before we enter upon a new period of industrial activity, so that the new construction that will be required may be coördinated with such a plan and developments that will not harmonize with the plan may be avoided.

This appropriation is requested not as a substitute for but as supplemental to the other estimate submitted by this department for the investigation of fuel and power problems covering the whole United States. Fundamental studies dealing with principles of power supply and fuel utilization are prerequisite to more intensive investigation of the kind that I am bringing to your attention in this letter.

The wording of the estimate for the proposed $50,000 requested by Secretary Lane is as follows:

GENERAL EXPENSES, GEOLOGICAL SURVEY

For a survey of power production and distribution in the United States, including the investigation of methods for the further utilization of water power, and the preparation of reports thereof, one-fourth to be immediately available (submitted) ....$50,000.

Pointers on Pumping Hot Water

BY M. A. SALLER

WHEN special pains are being taken to direct attention to and eliminate all sources of waste and inefficient operation in the boiler and engine plant, it is well to consider the folly of the still widely prevalent practice of introducing cold water into the pump supply line whenever trouble is experienced in pumping hot feed water. Steam is used to heat the feed water to the highest possible temperature because it is appreciated that a rise of 10 deg. in the feed will effect a fuel saving of approximately 1 per cent. After this is done, the engineer or fireman calmly injects cold water into the pump suction line in order to stop knocking in the pump. Instead of heating the feed water to a high point and then cooling it down so that it can be pumped without trouble, the logical thing to do would be to investigate the pump and the piping in order to remove the cause of the trouble, and thus be enabled to take advantage of the high feed temperature.

In pumping hot water it is necessary that the water should flow freely to the pump under head; that is, hot water cannot be lifted by the pump like cold water, because the reduction in pressure caused by the suction of the pump will increase the tendency of the hot water to vaporize and give off steam, which is the cause of the pump knocking. Therefore the first point is to make sure that there is a positive head of water from the heater or hot water tank to the pump. The distance between the level of the pump valves and the working water level in the heater should be not less than 36 in. If this positive gravity head is not available, the pump must be lowered or the heater raised. In some cases the difference in level between the hot-water supply and the pump valves may be 36 in. or more, and still the pump may "balk" at handling the hot water. This may be because the friction loss through the pipe between the heater and the pump is excessive. The piping between the heater and the pump should be of ample size—larger than would ordinarily be run for cold water—and should be as short and direct as possible. Gate valves should be used in the suction line, instead of globe valves, because they offer less resistance. When a long pipe run is necessary between the heater and the pump it should be made "extra large" and should be pitched continuously toward the pump so that there will be no air or steam pockets.

Trouble is often experienced in handling hot water because the pump is too small to handle the load. Pumps for handling hot water should be of such dimensions that the piston will not have to travel faster than 40 to 50 ft. per min. to maintain the desired capacity. If the piston has to travel at a high rate, difficulty will be experienced in keeping a solid body of hot water behind it unless a high head of water is available. If the passages through the pump chamber or valve seats are restricted, it will of course be more difficult for the water to follow the piston, and hence a higher gravity head will be required. If the pump piston travels so fast that the water cannot keep up with it, a partial vacuum is formed and the hot water gives off vapor and immediately the pump will begin to pound or knock because it is vapor- or steam-bound.

The valves of pumps often cause difficulty in handling hot water. The ordinary rubber pump valve deteriorates under the action of the heat. Pumps for handling hot water should have brass piston rods and metal or special composition valves. Trouble is also likely to occur if the springs on the pump valves are too stiff or tight causing undue friction in passing the water through, all tending to keep the water from freely following the piston. Where there is a long pipe line and the gravity head is small, it is advisable to erect a standpipe in the supply line near the pump so that a supply of water will be available right at the pump and under the maximum head. The standpipe can be made of a section of pipe extended above the highest water level, and it should be vented to the atmosphere to prevent airbinding. Centrifugal pumps require a greater gravity head than is necessary for reciprocating pumps because of the high velocity at which the water must travel. A head of eight to 12 feet should be available over a centrifugal pump.

Difficulty in pumping hot water is merely the result of overlooking one or more factors necessary to insure satisfaction. The main thing to bear in mind is that the hot water must follow the pump piston under gravity head, and to insure this the following points should be borne in mind: Place the pump below the heater or hot-water tank level; run ample size piping, slope the piping toward the pump, avoiding air pockets; eliminate all unnecessary valves and fittings in the supply line; use larger-sized pump for hot water than for cold; keep piston speed below 50 ft. per min.; use first-class metal or composition pump valves; reduce tension on valve springs until just sufficient to close the valves; if necessary place a standpipe near the pump, but do not inject cold water into the hot water line.

Firemen Saved U.S. Transport

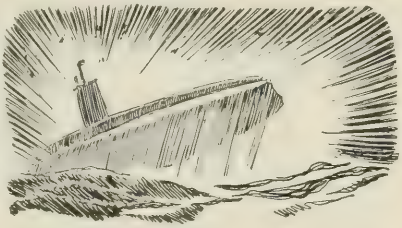
MIGHTY interesting stories are being told these days about how our American boys have upheld the honor of the U. S. A., but most of these stories are of deeds performed on the battlefields of France. There have been thousands of instances of brave and heroic deeds that will never be recorded, because they did not come to the attention of someone with a ready pen. Although most of the thrilling accounts relate to the army, the army-transport service has had its stirring experiences, one instance of which is as follows:

On the afternoon of Sept. 4, 1918, the U. S. Transport "Mount Vernon," formerly the German steamer "Kronprinzessin Cecilie," commanded by Captain Dismukes, left Brest, France, for New York, but the vessel was destined to participate in a voyage that was far from uneventful, and finally, after being torpedoed by a Hun submarine, reached port only because the firemen in the stoke hole stood by their fires like American seamen.

Upon leaving Brest all water-tight bulkhead doors below deck were closed so that in case the ship was torpedoed there would be a chance for it to remain afloat. This, of course, cut off the stoke holes from other portions of the ship, and one stoke hole from the other. By closing the water-tight doors all avenues of escape from the stoke hole were cut off except a precarious route by way of a ladder and over the boilers.

A route was taken to avoid so far as possible submarine dangers, and the first danger zone was safely passed, and the chances were that the trip would be continued in safety. The unexpected usually happens, and the "Mount Vernon" was no exception. The next morning after leaving Brest, at about 8 o'clock, the ship was steaming along in a calm sea, making about 20 knots, when the lookout saw a periscope on the starboard bow and the ship's guns began firing, as did the destroyers, but all submarines are not blown out of the water even when sighted. Although the steamer was under convoy, a torpedo struck and she at once began settling in the water, but fortunately, the water-tight doors held and prevented the undamaged portion of the ship from filling, although she settled about ten or twelve feet as the water flooded the damaged portion of the hull.

The engineer reported to the bridge that the engines were still running and that the means of communication with the bridge were intact, but that water was rushing into the fireroom and that there was great danger of a boiler explosion. Fortunately, but one of the firerooms was damaged. What happened in the stoke holes cannot be adequately described. Thirty-six of the fireroom crew lost their lives either by drowning or by being killed by the torpedo explosion, and many others were badly burned by the flames that shot out from the boiler furnaces when the water reached the fire. Fortunately, the inrushing waters helped to end their agony speedily.



In the undamaged boiler room all lights went out with the explosion of the torpedo, owing to the breaking of the electric-light wires. In the darkness, wallowing in water that covered the floor, blinded by fine soot and steam-pipe insulation, and injured by fine pieces of metal, working in fact in the face of almost certain death, these firemen and water tenders stood at their stations and proved themselves heroes. They knew

that they were trapped; they knew that there was danger of a boiler explosion that would completely wreck the ship should it occur, but not a man made a step toward safety. There in the darkness these men continued to stoke the boilers, using for a time the light from live coals or from a torch to determine the water level in the gage-glasses until such time as other illumination could be obtained. Through their heroic efforts the "Mount Vernon" was safely navigated back to port.

This is but one instance of the bravery shown by men who work down below deck, practically unheard of and unseen. It takes nerve to enable a man to stand by his station in times like this when he cannot see or obtain any information as to what is going on about him. Darkness adds terror to any situation, and all honor is due to these men who stood by their station under conditions that called for as much, if not more, heroism than is required to storm a defended position on the battlefield.

Improved Blonck Boiler Efficiency Meter

The coal shortage of last winter and the efforts of the United States Fuel Administration to conserve fuel have given a strong impetus to improvement in power-plant economy. This has been indicated by the increasing demand for instruments of all kinds. Partly because of this increased demand and partly because a new principle has been developed, the improved meter shown at the right in Fig. 1 has been put on the market by W. A. Blonck & Co. At the left of this view is one of the original meters made by the company. Fig. 2 is an enlargement of the new meter.

A primary feature of the new design is that the readings are unusually easy to observe and to interpret. In the older type of Blonck meter no effort was made to supply ranges of scales designed to have the arrows opposite to each other. The latest type is based on the idea of "Each meter built to fit the drafts of the boiler to which it is connected." This results in the indicating oil columns standing one over the other for the highest efficiency of combustion. Hence the fireman need know nothing of the principles of combustion so long as he is capable of manipulating the damper and thickness of fuel bed to maintain the columns of oil in line. The minute they get away from each other it is a simple matter for him to refer to a guide, printed on the face of the gage, determine what the trouble is and institute corrective measures.

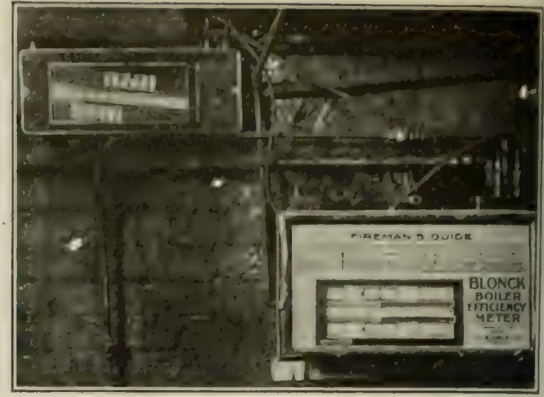


FIG. 1. SHOWING OLD AND NEW METERS

Parallel motion of the two liquid columns is obtained by variation in the calibration of the back leg of each tube, as shown in Fig. 3. As the loss in draft through the fire is the factor varying between the widest limits, the back leg of the lower gage is made of nearly the same diameter as the horizontal leg, so that the movement of the fluid in the horizontal leg is retarded. On the other hand, as the drop in draft from the furnace to the damper is less than that through the fire, the back leg of the upper gage is made larger in diameter so that the movement of the fluid in the horizontal leg is accelerated. This simple device for making the two columns of oil travel uniformly together when the ratio of air supply to pounds of coal burned per hour is correct and the instructions for correcting conditions when they become wrong, are the two factors favoring the new meter. A minor refinement is the arranging of the tubes in a horizontal instead of an inclined position, as was the case in the old gage. This is accomplished by putting a slight loop in the tube at the point where the horizontal changes to the vertical. The meter is easily read and the directions simplify the furnace management.

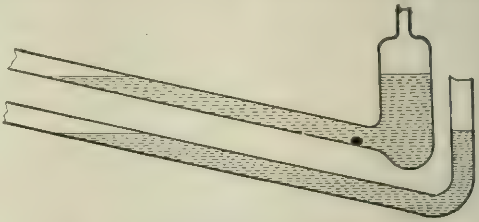
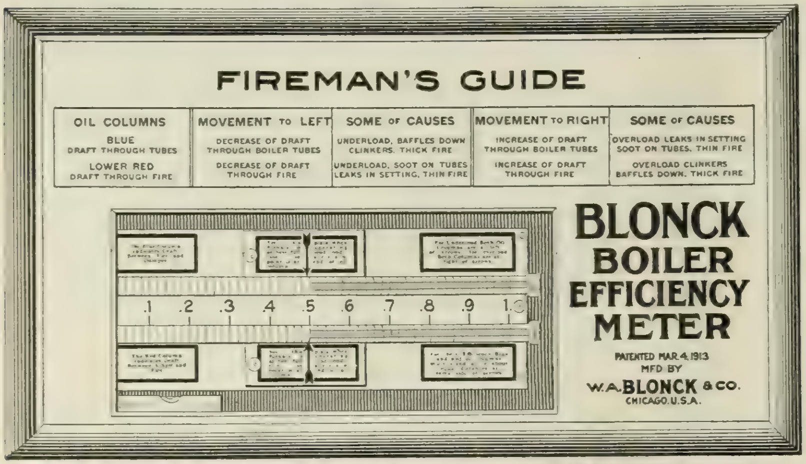


FIG. 3. BACK LEGS OF METER TUBES



FIREMAN'S GUIDE

OIL COLUMNS	MOVEMENT TO LEFT	SOME OF CAUSES	MOVEMENT TO RIGHT	SOME OF CAUSES
BLUE DRAFT THROUGH TUBES	DECREASE OF DRAFT THROUGH BOILER TUBES	UNDERLOAD, BAFFLES DOWN CLINKERS, THICK FIRE	INCREASE OF DRAFT THROUGH BOILER TUBES	OVERLOAD LEAKS IN SETTING SOOT ON TUBES, THIN FIRE
LOWER RED DRAFT THROUGH FIRE	DECREASE OF DRAFT THROUGH FIRE	UNDERLOAD, SOOT ON TUBES LEAKS IN SETTING, THIN FIRE	INCREASE OF DRAFT THROUGH FIRE	OVERLOAD CLINKERS BAFFLES DOWN, THICK FIRE

FIG. 2. ENLARGED VIEW OF THE METER SHOWN AT THE RIGHT OF FIG. 1

EDITORIALS

Providing an Ample Power Supply for Peace Industries

FOREHANDEDNESS is a characteristic that was noticeably lacking in the United States at the time we entered the great war, and because of that fact we were slow in making our weight felt in the struggle. We had taken little or no thought as to the methods of raising armies, constructing ordnance, building airplanes, extending transportation facilities and meeting the thousand and one other increased demands upon our industrial machinery.

Those were problems brought about by the war, but they were solved eventually, by dint of much hard labor and at vast expense. Now we are confronted by equally important questions that have arisen as a result of the war and that are pressing for solution. Among them the problem of an ample and intelligently arranged system of power generation looms large, because the prosperity of the country is intimately bound up with the matter of power supply to industry.

The requests of the Secretary of the Interior for appropriations for a survey of the power situation in the United States, as explained on page 211, are therefore commendable examples of foresight. Especial interest attaches to the larger of the two appropriations asked for, because it is concerned with investigation of the most densely populated industrial district in the country; namely, the northern Atlantic seaboard. In this narrow strip of territory the greater part of the manufacturing of the nation is concentrated, with the result that there was a serious shortage of power when these plants tried to meet the output demanded by war conditions.

Secretary Lane's plan is intended to prevent the recurrence of this condition under the stress of industrial expansion to meet peace-time needs. It embodies those features that have been found economical and efficient in operation during the war period. It looks forward to the generation of electrical energy by steam plants in the coal fields and by water-power plants wherever they can favorably be built, with interconnection through a trunk-line system. The desirability of a comprehensive system of this kind, by reason of the diversity factor and the freedom from shutdowns due to shortage of power, needs no demonstration to engineers.

The Secretary plans even more than this, however. He sees the eventual electrification of the railroads in the congested area, thereby relieving them of the transportation of a considerable quantity of coal and at the same time conserving the fuel supply by reason of the difference between the efficiencies of the locomotive and the electric generating station. This reduction of the burden on transportation would help to relieve a situation that has been critical for a long time.

The need of a survey such as this appropriation would render possible is beyond the necessity of proof. But no time should be lost in carrying out the work, if its findings are to be of immediate value. It seems to be very generally believed that the country is about to enter upon a period of industrial activity and prosperity such as it has never seen, and power is at the base of the whole industrial structure. Therefore, if we are to meet the new demand with a system of power-producing plants scientifically arranged and coördinated, prompt action is necessary.

Unpreparedness for the duties and responsibilities of waging war cost us heavily in time and money. It is to be hoped that we have learned a lesson from that experience and that we shall enter upon the era of industrial expansion securely fortified against lack of power. The Geological Survey and the Bureau of Mines, under whose guidance the power investigation would be made, have the necessary organization and the experience. They lack only the needed funds and those should promptly be forthcoming.

Carbon-Brush Characteristics

AS EARLY as 1885 carbon brushes were suggested for use on electrical machinery in a patent taken out in that year, and about two years afterward they came into use and are still with us—in a greatly improved form. When we compare the characteristics of the old copper-gauze brush, with all its sparking and arcing, cutting commutators, the necessity of shifting the brushes with each change of load to obtain commutation, etc., with the results obtained with a modern carbon brush applied to the service for which it is designed, the improvement is almost phenomenal.

That the carbon brush has played an important rôle in the development of the electrical industry, especially of direct-current machinery, is generally recognized, and if it had not been for the carbon brush no doubt development of direct-current electrical equipment would have lagged while that of alternating-current apparatus would have been accelerated to even a greater extent than it has.

Many of the types of direct-current machinery in use would be impossible of commercial development without the use of carbon brushes or material of similar characteristics. Chief among these are the high-speed turbo-generator, the sixty-cycle rotary converter and the high-voltage direct-current railway machinery.

However, for many years little consideration was given to the distinctive features of carbon brushes; coefficient of friction, hardness, abrasiveness, lubricating qualities, contact resistance, etc., were practically alien to the art, and only within the last ten or twelve years has real serious consideration been given to the development of different grades of brushes to meet the different classes of service and the various types of machines. The possibility of a universal brush is today in the same category as that of a universal motor—both have passed into the realm of things apparently impossible.

As long as brushes were used without any consideration of their suitability to the service to which they were being applied, all kinds of commutator troubles were experienced. If a nonabrasive brush happened to be applied to a commutator with hard or too thick mica, blackening and a burning of the commutator was the result. The brushes were often blamed for the trouble; more frequently the quality of the commutator was blamed because of the mica being too hard, when in fact both were contributory causes. Today we know the remedy is to undercut the mica if operating conditions will permit, or else to use a brush that possesses sufficient abrasiveness to cut down the mica.

Undercutting the mica in a commutator has gone a long ways toward improving the results obtained from different types of brushes. At one time graphite brushes were condemned for certain classes of service and looked upon with disfavor in others; today by undercutting the commutator mica they are considered equal if not superior to other grades for these same applications.

Another practice that was the cause of considerable trouble was working the brushes at too high a current density, and that is probably not given the consideration today that it should receive. This trouble generally developed after the machine had been in service for a considerable period, due to the heating of the brushes drying out the lubricant. In many cases the trouble was corrected for the time being by giving the commutator and brushes a bath of oil. This is now considered very bad practice, and brushes of the proper characteristics are selected.

Instead of the old idea that any carbon brush was suited to any service, it has come to be recognized that there is one best grade of brush for each class of service. Beginning in this issue on page 202 is the first of three articles on the "Characteristics, Composition and Application of Carbon Brushes to Electrical Machinery." These articles are unique in their treatment in that they not only tell what the characteristics are, but also show how they are determined by tests and are obtained in the composition of the brush, hence giving a deep meaning to this element that is so essential to the satisfactory operation of electrical machinery.

The Revised A. S. M. E. Boiler Code

ON PAGES 196 *et seq*, is given a résumé of revisions which have been made in Part I, Section I, relating to new installations of power boilers, of the Boiler Code of the American Society of Mechanical Engineers. These revisions are the outcome of four years of practical application of the Code. Frequent meetings have been held by a large committee of experts and specialists in the various phases of the subject, comprising boiler manufacturers and users, manufacturers of boiler materials and appliances, designing and consulting engineers and inspectors, both insurance and governmental, for its interpretation and modification. By this activity the society has placed at the service of the profession, of governmental inspection departments and of legislators who are considering measures of public safety, an instrument embodying the best thought, knowledge and experience of the profession, the cost of which, if the labor expended upon it had been requited at the rates ordinarily paid for such services or measured by the actual worth of the time of its constructors and interpreters, would approach a half million dollars.

In addition to the work of these experts we should like to bring to bear upon the evolution of this Code the practical thought and experience of *Power* readers. Send and get a copy of the complete Code from the Secretary of the American Society of Mechanical Engineers, 29 West Thirty-Ninth Street, New York. The charge is one dollar to nonmembers. Then see how nearly the boilers under your care comply with its requirements. Such a process leads to interesting engineering computations and to a new intimacy with one's plant. This kind of knowledge and the competency to apply it broadens a man and increases his value. If there is anything about the Code or its applications that you do not understand or approve of, or if any suggestions occur to you for its betterment, write to the editor. The Code ought to be clear and understandable to and workable by any of *Power's* constituents, and its extensive and intelligent application by *Power's* constituency would prove its worth or be the best means for pointing out further desirable changes. We hope to see it universally adopted.

If we call the coal operator a profiteer when he makes a profit of $1.10 per ton, what are we going to call the owners of the coal fields who charge as high as $1.50 per ton for the mere privilege of taking out of the ground that which nature has so bountifully bestowed upon us, as brought out recently in the United States Senate Committee investigation of conditions in the anthracite fields?

It has been estimated that it costs one large corporation from forty to one hundred and fifty dollars to hire and train a new workman, therefore this amount is lost if he is discharged or if he leaves of his own accord. From this it would seem that it would be a paying proposition to maintain attractive working hours and to put out a satisfactory pay envelope.

There was a time when boiler efficiency appeared to depend largely upon peculiar tube arrangement. Now attention is being given to proper furnace design and to proper baffling. In focusing attention upon furnace design, engineers are attacking the problem from the right angle.

You cannot improve efficiency by taking indicator diagrams from your engines and records from your CO_2 apparatus and filing them away. They are only guides and helps to a system of management that you must devise, impress and maintain.

Plan your future on the assumption that the present high prices are not going to fall. If they do, you'll be agreeably surprised; and if they do not, you won't be disappointed.

CORRESPONDENCE

Heating System Gradually Improved

In common with other engineers the writer has for years past spent considerable time in study and planning and more than one problem has been gone over and solved during the hours intended for sleep—not the wisest plan from a physical standpoint perhaps, but nevertheless "we all do it" at times.

One heating system, like Topsy, "had just growed," judging by the manner in which the piping was done. In the original design two 6-in. pipes with globe valves led from the two horizontal return-tubular boilers and joined at a 6 x 6 x 5-in. tee from which a 5-in. pipe led. Imagine two 6-in. pipes supplying one 5-in line! On this 5-in. line there was a reducing valve lowering the pressure to 15 or 16 lb. This valve had a rubber diaphragm which frequently blew out—on a cold night about 2 a. m. Just beyond this reducing valve there was a 5-in. connection to the 6-in. exhaust main. This connection was not used, however, as the exhaust steam was only used to heat the coils of a large blower which furnished hot air for some of the shops and dry rooms. There was a lot more exhaust than could be used in these coils, but it could not be utilized in the main heating system because it was necessary to supply higher pressure and temperature in some of the processes, although it was proved that 8 lb. was plenty instead of the 15 lb. formerly used. The condensation from the exhaust was wasted, although the engine, a simple Corliss, developed about 130 hp. and required at least 26 lb. of water per horsepower-hour. This condensate contained 4,732,000 B.t.u. per day of 10 hours, figuring from 60 deg. for raw water to 200 deg. for the condensate, equal to about 400 lb. of 12,000 B.t.u. coal that cost $3.90 per ton in the boiler room.

To get back to the piping layout, the 5-in. line after passing several ells rose vertically about five feet, this riser having a 2-in. drain valve to the returns. The valve was fastened so that the amount of opening could could not be changed, as the employees seemed to like to turn the wheel for pastime regardless of the effect on the heating system. The 5-in. line then split into a 4-in. running north and a 3-in. south, the latter being reduced a short distance farther on to 2½ in., which size was carried about 200 ft., where it divided into several branches. The 4-in. line was carried about 300 ft. without drains to a riser, full size, several branches being taken off without valves on them, making it necessary in case of needed repairs to shut off the whole line. At the extreme northern end there was a 2-in. drain. What course of reasoning would cause a man to think a 4-in. line would condense enough steam to require a 2-in. drain pipe?

The returns from all buildings were connected to the return main without valves—a very poor arrangement, particularly when repairs were necessary in cold weather. All condensate flowed by gravity to a receiver, thence by a pump to the boilers. All supply pipes with the exception of a few short sections exposed to outside temperature were uncovered. The radiating surface was equal to about four miles of 1-in. pipe. The pipe in one building, being actually measured, equaled over 5000 ft. of 1-in. pipe, and there were five other buildings of nearly the same size.

Little by little the pockets were removed, the drains connected and the pipe covered. During this period, however, about 15,000 ft. of additional piping was installed. Although efforts were made to utilize the exhaust, nothing was actually done until about two years ago, when the closed heater was replaced by one of the open type. The returns from the blower coils, as well as the live steam condensate, were led to it and the receiver formerly used was discarded. Then additional coils were connected to the exhaust main. About a year later a cross-connection was made between the live and exhaust systems so exhaust could be used during the day and live steam at night. This necessitated the opening and closing of several valves each night and morning, but proved successful in relieving the situation. The exhaust from two air compressors, a Corliss and a high-speed engine and the feed pumps was all piped to the heater, and there was an abundant supply of exhaust. This improvement resulted in sufficient appropriation of funds to change the entire system.

It might also be said that tests made without the knowledge of employees, using steam in the process, showed that it was unnecessary to carry 14 to 16 lb. on that line—that 8 to 10 lb. was plenty. The changes were not radical or extreme, although effectual, consisting in extending high-pressure distributing lines to feed into the low-pressure system through reducing valves at remote points in the several buildings. This same line supplied the steam used in the processes and then discharged into the heating system. By this means the heating steam pressure could be again reduced so as not to put excessive back pressure on the engine. There is at all times during working hours an abundance of exhaust steam, the temperature of the feed water rarely drops below 190 deg. and it is usually over 200 deg. All coils and drains are equipped with traps of the thermostatic type, and all returns, from whatever device, are connected to a receiver from which the condensate is taken by a vacuum pump and discharged into the heater. Although we are getting inferior fuel and have a larger heating and mechanical load, a comparison of coal consumed with that of the corresponding period four years ago shows practically the same tonnage. Other improvements not bearing directly on heating have been made in the boiler room, and whereas only a short time ago it was difficult to keep firemen, the work is now so much easier that this trouble has disappeared. It took years of hard work planning and persuading, but everyone concerned is financially benefited as a result.

Trenton, N. J. HARRY H. YATES.

Tempering Coil Thermostat Set Wrong

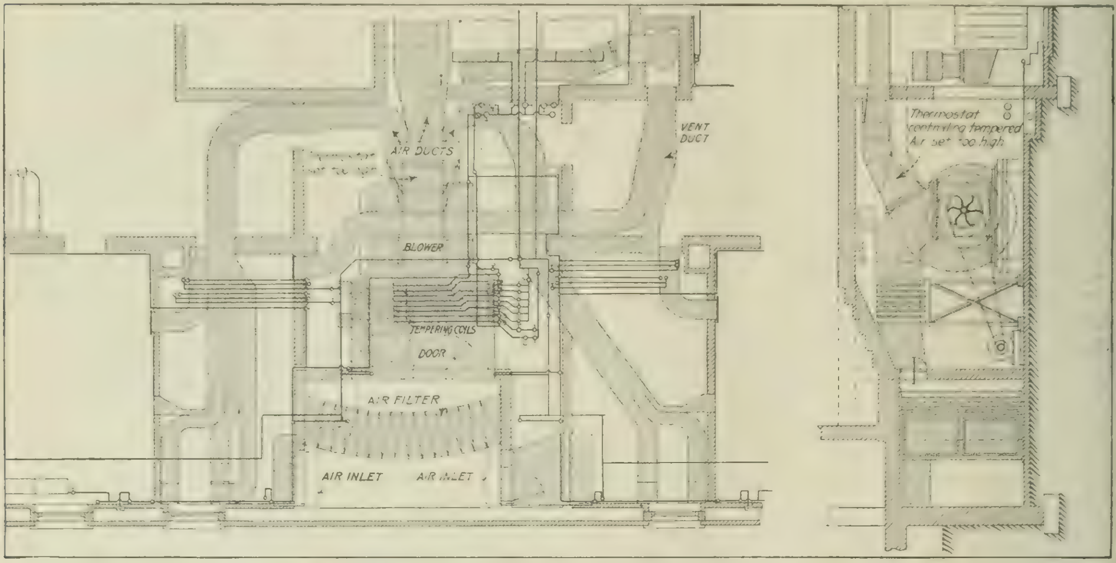
A thoroughly first-class heating system was installed in a school building, tested out by the designing engineers and passed. Some time later one of the engineers of the firm, having business in that town, called on the school superintendent to inquire how things were going. He found that worthy "all het up," figuratively, on account of the failure of the heating and temperature-control systems to function properly. He said that the rooms were too hot and that it seemed impossible to keep the heat down. They were operating the blower system, although the weather was mild, supposedly to get ventilation. The illustration shows the general layout of the heating plant. Thermostats controlled the steam to the direct radiators and also to the tempering coils. Upon investigation it was learned that the thermostat for the tempering coils was set at about 105 deg., so that the air delivered by the fan and duct system was so hot that the rooms were overheated even when the direct radiation was all shut off. The remedy was of course simple and easily applied—when the tempering coil thermostat was adjusted to about 65 deg., there was no difficulty from overheating. The following instructions were then supplied, and no further difficulty has been experienced:

We take pleasure in furnishing you the following notes, which may be helpful in the operation of the heating and ventilating plant of your new school building.

Generally speaking, in the milder weather the heating of the building is to be effected by steam radiators only, but in colder weather the air supplied by the ventilating apparatus must assist the heating. The radiators placed in the classrooms have been figured to heat the rooms to only 60 deg. temperature when the outside temperature is between 0 and 10 deg. F. During extremely cold weather the air supply should therefore be kept at a considerably higher temperature than the room temperature—say at 85 to 95 deg. At higher outside temperatures the air supply should be kept around 70 deg. Thus, for instance, on a day of 40 deg. the air should be about 65 deg., but when the outside temperature is around 20 deg. the air supply should be about 75 deg. These figures are only illustrative and should be slightly varied if the best results are secured under somewhat different conditions. As to the thermostats, we wish to reiterate that the less they are manipulated the more satisfactory will be the automatic control of the heat. Should a teacher desire a temperature of 68 deg., the thermostats should be adjusted and left to operate at that temperature and not adjusted to the momentary feelings of the teacher. We advise you to make arrangements with the makers for one or two yearly examinations of the thermostats.

If the schoolrooms become very cold in the morning and conditions should again maintain as last year, when the room temperatures sometimes went below the freezing point, we ask you not to forget that the school can be heated very rapidly by hot air recirculated by the blower. It will be necessary to shut the air-inlet dampers and open the doors between the blower rooms and the basement playrooms, but shut the door between boiler and blower rooms and then run the fan, circulating the air in the building in this manner. We recommend that on very cold days the vent registers be closed. These flues are all located on the inside walls and are consequently not subject to any chilling which might retard the air flow. The capacity of flues depends upon the difference of temperature between the inside and outside air, and the flues therefore become very active in cold weather, because of the extreme temperature difference. The large amount of air drawn from the classrooms by these flues may well be responsible for cold classrooms in the morning. As to the air-inlet dampers, they should be carefully shut off overnight, so as to prevent freezing up the tempering coils, in case of any accumulation of water in these coils, due to leaky valves, etc. Your engineer should be instructed never to open the air inlets unless he has a pressure of at least one pound on the boiler; then if the air valves are properly adjusted, an active steam circulation is certain and freezing and damage is prevented. **J. Lewis.**

New York City.



GENERAL ARRANGEMENT OF AIR-TEMPERING EQUIPMENT WITH THERMOSTAT TO REGULATE TEMPERATURE

Cost of Banking Fires

Having read the editorial, "Cost of Banking Fires," in the Jan. 14 issue of *Power*, I offer the following, based on the records of the plant of which I have charge. It does not seem as though the cost of banking coal used should be charged directly to the cost of producing power, but some disposition must be made of this item, which amounts to a considerable in a year.

I am of the opinion that estimating one-third of the coal used for the day's run is used for banking purposes is excessive, at least it is in our plant. If there are no records, it is difficult to estimate with any degree of accuracy.

This plant is not one of the large stations, but daily records are kept of all operations, supplies, water, etc., and perhaps some information can be deduced from our experience. We have two 125-hp. hand-fired return-tubular boilers operated alternately, under forced and induced draft.

A mixture (about half-and-half) of hard-coal screenings at $2.25 per ton and nut and slack at $4.60 per ton is burned, averaging about $3.50 per ton as fired. An average of 2.75 tons of fuel is burned daily.

The fires are run 12 hours daily, then burned down and banked with straight nut and slack coal, an average of 275 lb. being wheeled out while the fire is brought down and is dumped before the boiler separate from the day's run coal and there is seldom more required.

Operating 360 days a year and banking coal at $4.60 per ton means 49.4 tons used, costing $228 per year for banking. With a coal consumption averaging 880 tons an estimate of one-third is excessive.

Rochester, N. Y. C. M. Bourcy.

A Cooling Pond Suggestion

I once had an opportunity to observe the waste of steam and coal resulting from high-temperature injection water while on testing work on a 10,000-kw. turbine unit. The condenser had 10,000 sq.ft. of cooling surface and the cooling pond was designed to be of ample capacity, but it proved inadequate in hot weather and only about 6500 kw. could be carried on the turbine during the summer when the outside temperature was 82 to 85 deg. Whenever the load exceeded 6700 kw., it was necessary to run the spray-nozzle pressure up from 9 to as high as 19 lb., and under these conditions the vacuum would drop to 23 or 24 in. Temperature readings taken in the center of the pond were far above the air surrounding the pond even when the wind was blowing briskly. It occurred to me that additional nozzles set 10 to 12 ft. higher than the rest would improve the cooling effect quite materially. Tests proved that reducing the number of nozzles reduced the volume of water circulated, but increased the injection temperature greatly; hence it would seem reasonable that increasing the number of nozzles would also increase the volume of water circulated by speeding up the steam-driven circulating pump.

I would like to hear from readers of *Power* who have had experience along this line.

Franklin, Ohio. Waldo Weaver.

Calculating Heat Loss in Water

A few months ago an insurance inspector made a report that there was oil in our boilers. As we use exhaust steam to heat the building, we decided to trap the returns to the sewer. A few days later an inspector from the Fuel Administration came to view the plant, and he said that we were wasting coal by letting the heating returns go to the sewer.

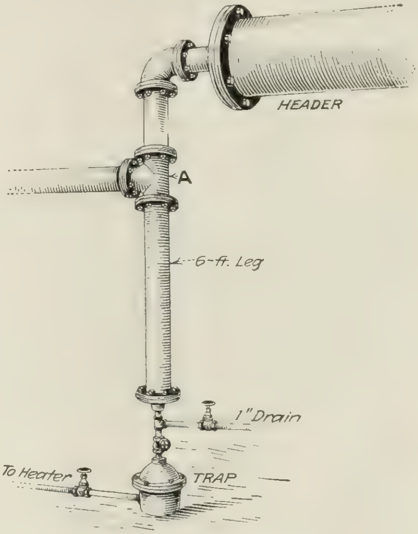
We have a closed heater, and all the steam passes through this heater before it heats the building. The boiler-feed pump is going at a steady rate, and the water going through the coil in the heater has plenty of time to get heated to the same temperature as the steam passing through. I believe we only lose the water going in the sewer and would like to know through *Power* how much heat, if any, we are losing by letting the heating returns go into the sewer. The trap discharging the returns does not leak steam.

New York City. Patrick Molloy.

Changes Improved Matters

When the steam-supply line to a new 250-hp. unit was put up, the chief was on sick leave, and the steamfitters ran the line and connected it to the header, as shown by the sketch, using an elbow at *A*. When this unit was put in operation, large slugs of condensation from the header would carry over, causing frequent shutdowns during the day.

On returning to the plant, the chief, to overcome this trouble, shut down the engine and put a tee in the line as shown at *A*, in place of the elbow. He then connected a 6-ft. leg to the tee, connected a trap to the leg and piped the trap to discharge to the heater. The results were very satisfactory.



ARRANGEMENT OF THE HEADER PIPING

The exhaust steam from this unit was allowed to escape to the atmosphere. After a few weeks' run, increasing business demanded that the unit be run at night and more coal was consumed than was necessary. During the day run other units supplied exhaust steam to the feed-water heater, keeping the feed water up to 210 deg. F., but at night these engines were not run, with the result that the temperature of the feed water fell to 50 deg. Fahrenheit.

The chief secured a back-pressure valve and installed it in the exhaust line of the new unit, and the exhaust steam was passed through the open heater, with the result that the temperature of the feed water was raised to 210 deg. Fahrenheit.

In round figures the saving on the coal bill averaged about $80 per month. This put a smile on the superintendent's face and another feather in the chief's cap.

Memphis, Tenn. J. A. Landolina.

Avoid Unnecessary Pumping

In many buildings coal can be saved by a proper arrangement of the water piping so that water directly from the city main supplies the lower floors, instead of discharging into a suction tank, necessitating pumping it from that tank to the entire building. The lower floors can be piped separately from the upper ones, and the house pumps will have that much less to do, thus saving wear and tear on the pumps as well as coal. Sometimes it may be advisable to connect the suction pipe of the pump with the city mains direct, in which case it should be of ample size to give full pressure and volume at the pump, thus reducing the work that the pump will have to do. It is advisable to install a gage on the suction pipe to observe the pressure.

When filters are installed in the line, gages should be connected on both inlet and outlet of the filter to show the drop in pressure through the filter bed and to indicate when the filter needs cleaning, and also when the fish trap, meter or any part of the supply line gets clogged. W. T. MEINZER.

Brooklyn. N. Y.

Centrifugal Pumps Made with Wooden Casings

I have read a number of articles relating to centrifugal pumps, but I have not seen anything about their being made with wooden casings. I have built a number of such pumps, using bronze impellers, and they have given excellent service in coal mines.

On a wooden casing sulphur or mine water has an opposite effect to that which it has on a metal one. In the latter it eats away the metal, but on a wood casing it forms a scale which increases in thickness with the life of the pump; this causes the leakage around the impeller to remain more nearly constant as the impeller wears away.

I built the first one of these pumps in 1915, and it has been in operation from 12 to 18 hours every day since then. The first impeller put in this pump was of cast iron, but the others were made of bronze, the third one being put in about a month ago. Where this pump is used the water contains so much acid that a cast-iron pump would last only about two weeks.

When the first bronze impeller was put in, I also put in a bronze shaft, but being designed for load only, it wore so much at the stuffing-box that it broke off in about six months. Since then I have been using a steel shaft, which wears less in the stuffing box and lasts from four to five months. This is a 4-in. pump and works under low pressure.

Since building the first pump, I have been using a shaft with large cross-section, which stands more wear at the stuffing-box before getting too small to carry the load.

One pump, 5 x 6 in., with a bronze shaft, was in service 12 to 18 hours a day for about 13 months before being repaired. The impeller was badly worn, but would have lasted two months longer.

These pumps are all of the side-suction type. I have designed an impeller that is water-balanced when under load. A thrust bearing is used for protection when starting the pump, and also when the water is pumped low enough for air to enter the suction line, which causes the pump to lose its load and allows the water to run back through the pump in case the foot valve becomes worn. This makes the impeller pull toward the suction side and wears into the case unless the pump is stopped. One of these pumps (a 5 x 6-in.) is working on a line 4000 ft. long against a 40-ft. head.

Most builders of centrifugal pumps put the stuffing-box at the end of a long sleeve, which wears and causes the shaft to have considerable spring on account of the impeller being so far from the bearing. With this springing of the shaft the packing soon wears away and allows the pump to take air in at the shaft, which causes it to lose its water.

I put the stuffing-box as close as possible to the impeller and thus avoid considerable of this trouble.

Rimersburg, Penn. J. A. SHAW.

Wrong Piping Layout

Commenting on the letter by D. T. Brown, page 65, in the issue of Jan. 14, the most interesting thing to me is not the phenomenon of varying water levels when cutting such boilers into service, but how long such a piping connection as is shown was allowed to exist before being corrected and what manner of engineer was responsible for the installation originally. It all serves to emphasize the necessity for some form of inspection, by competent men, of all boiler and piping installations.

Had the boiler been cross-connected between the two drums and the cross-connection coupled to a common outlet, the installation would have cost less and been safe, whereas the connection as shown is an invitation to disaster. In connection with the subject of correct piping layouts I am prompted to describe a condition that existed for years in two power plants with which I am familiar. Centrifugal boiler-feed pumps were connected to a common feed line, with one or more pumps of like kind or duplex pumps, without a check valve on the discharge of the centrifugal pumps. Such a connection allowed the water to be short-circuited from the discharge of other units back through the centrifugal pump in case the suction and discharge valves on the centrifugal unit were opened before the pump was brought up to speed. This sometimes resulted in loss of feed to the boilers, if the mistake in operation was not promptly discovered. This condition is easily corrected by a check valve in the centrifugal-pump discharge line. C. B. HUDSON.

Holyoke, Mass.

Generator Heats Excessively

In the Jan. 21 issue of *Power,* page 102, Peter Burkard, writing under the title, "Generator Heats Excessively," requests information regarding the cause of the trouble. I would suggest that he examine the air gaps between the armature and polefaces, for it is apparent that the armature is rubbing on the polepieces. This does not have to be sufficient to injure the armature mechanically, but just enough to cause the necessary friction to produce the heat complained of.

Huron, S. D. J. N. CHALLACOMBE.

INQUIRIES OF GENERAL INTEREST

nergy of Coal Utilized by Engine—With an evaporative nomy of 8 lb. of water per pound of fuel containing 00 B.t.u. per pound, what percentage of the energy tained in the fuel required for generation of steam is ized by an engine that consumes 25 lb. of steam per icated horsepower-hour? F. G. G.

ne B.t.u. is equal to 778 ft.-lb., and the energy contained a pound of the coal would be 10,000 × 778 = 7,780,000 lb. With an evaporative economy of 8 lb. of water per nd of coal the energy used for the generation of 25 lb. team would be 7,780,000 × 25 ÷ 8 = 24,312,500 ft.-lb. As horsepower-hour is equal to 33,000 × 60 = 1,980,000 lb., the percentage of fuel energy realized by the engine ld be 1,980,000 × 100 ÷ 24,312,500 = 8.14 per cent.

emi-Bituminous Coal and Semi-Anthracite—What are the racteristics of semi-bituminous coal and of semi-anthra- ? W. R. P.

emi-bituminous coals resemble anthracite more closely n the bituminous, but are lighter and kindle and burn e readily, giving off an intense heat with little smoke make a clean good fire with little attention. The analy- of semi-bituminous coals is about as follows: Fixed bon, 70 per cent.; volatile matter, 16 per cent.; sulphur, per cent.; ash, 12 per cent. Coals containing 7 to 12 cent. of volatile combustible matter are classed as i-anthracite. They burn freer, are lighter, not so hard have less metallic luster than true anthracite, showing n analysis about 89 per cent. fixed carbon, 7.5 per cent. atile matter and about 3.5 per cent. ash.

elocity in Pump Discharge Line—Having a duplex pump h water cylinders 4 in. diameter and 6 in. stroke and h piston making 100 single strokes per minute, what ld be the velocity of the discharge in a 2-in. discharge working against a pressure of 80 lb. per square inch? N. S.

ithout allowing for the space taken up by the piston s, the area of each piston would be 4 × 4 × 0.7854 = 66 sq.in., and with each piston making 100 single 6-in. okes per minute, the total piston displacement would be 66 × 6 × 100 × 2 = 15,079.2 cu.in. per min. The ssure that the pump works against and other conditions ld influence the percentage of slip which under average ditions amounts to about 5 per cent., and the actual ume discharged would be about 15,079.2 × (1 − 0.05) 14,325 cu.in. per min. As the cross-sectional area of a . discharge line would be 2 × 2 × 0.7854 = 3.1416 sq.in., velocity in the discharge line would be 14,325 ÷ (3.1416 12) = 379.9 ft. per min. or about 6⅓ ft. per second.

econnecting a 500-Volt Motor for 220-Volts—I have a p. 500-volt shunt-wound motor and wish to reconnect o operate on a 220-volt circuit; how can this be the most ily done? The armature is series-wound with only two s of brushes on the commutator. C. K. B.

o doubt the most satisfactory way to do this would be connect the armature coils in a single parallel winding l the field coils in two groups of two in series and the ups in parallel. The motor will now require a new brush r that will accommodate four sets of brushes instead two. These can be secured from the manufacturer of machine.

Another way of reconnecting the armature, if the brushes thick enough to span at least three commutator seg- nts, is to connect the armature coils in a double series nding. This would allow the use of the same brushes, there is always a greater possibility of commutator uble using this type of winding, consequently additional ense for brush gear required for the single parallel nding is a good investment.

Unbalanced Load on Three-Phase Circuit—A three-phase Y-connected alternator supplies an unbalanced load to a three-wire circuit. The ammeter readings in each of the three phases are 10, 6 and 5 amperes respectively. The load is noninductive and the voltage 2300 between terminals. What is the total power delivered by the alternator? I. R. S.

The answer to this problem may be obtained in two ways. First, find the average reading of the ammeters, which in this case is (10 + 6 + 5) ÷ 3 = 7 amperes, and consider this as a balanced load equal to the average value obtained. Then, when the load is noninductive,

$$Kilowatts = \frac{volts \times amperes \times 1.732}{1000} = \frac{2300 \times 7 \times 1.732}{1000} = 27.89$$

The second method is to calculate the kilowatts per phase. When the load is noninductive, $Kw. = \frac{EI}{1000 \times 1.732}$, when $Kw.$ is kilowatts per phase, E volts between terminals and I amperes per terminal. In this problem the kilowatts in each of the three phases are $\frac{2300 \times 10}{1000 \times 1.732} = 13.29$, $\frac{2300 \times 6}{1000 \times 1.732} = 7.96$ and $\frac{2300 \times 5}{1000 \times 1.732} = 6.64$ kilowatts respectively, or a total of 13.29 + 7.96 + 6.64 = 27.89 kilowatts.

Series Motor Connected as Shunt Machine—I have a 110-volt small series motor that runs at about 2000 r.p.m. I tried operating this machine with the field coils connected in parallel with the armature, thus converting it into a shunt machine. The motor then got very hot and the speed dropped to 1150 r.p.m. What caused the change in the operation of the machine? A. A. F.

The field coils of a series motor always have a comparatively low resistance and are connected in series with the armature as in Fig. 1, consequently the conductors must have sufficient cross-section to carry the armature current without overheating. When running as a series machine, the current through the field coils is limited by the counter-electromotive force of the armature and not by their resistance.

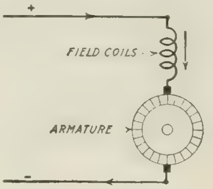


FIG. 1

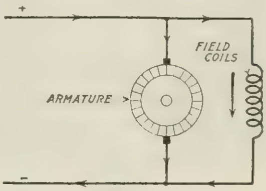


FIG. 2

If the field coils are connected in parallel with the armature, as in Fig. 2, which is the condition in a shunt machine, they have full-line voltage applied to their terminals and the current through them is now limited only by their ohmic resistance. The resistance of the coils being low, the current is very high and consequently they become very hot. In the case of large series motors, connecting the field coils across the line practically amounts to a short-circuit. In the case of small series fan motors, if the circuit is fused high enough, the field coils can remain connected across the line for a few minutes before the temperature becomes high enough to injure the insulation.

The decrease in speed was due to the increased current in the field coils building up the magnetic density to a value where the armature would generate practically the same counter-electromotive force running at 1150 r.p.m. as a shunt machine at 2000 r.p.m. operating as a series motor.

Annual Meeting of the American Society of Heatin and Ventilating Engineers

THE twenty-fifth annual meeting of the Society of Heating and Ventilating Engineers was held at the Engineering Societies' Building, 29 West 39th St., New York City, Jan. 28, 29 and 30 and was attended by about 150 delegates.

The opening session was one of the most enthusiastic on account of the announcement of the chairman of the Committee on the Bureau of Research that the goal of $10,000 per year for five years had been reached—in fact, passed—so that the establishment of a research laboratory by the society is assured. Another report that is a source of gratification is the substantial increase in membership of 300 in the last two months, making the total membership about 1200 with the new slogan of 2000 members by 1920.

GROUP OF HEATING AND VENTILATING ENGINEERS AND GUESTS AT THEIR ANNUAL DINNER DANCE

The order of business in the opening session, beginning at 2 p. m. Tuesday, Jan. 28, was the appointment of tellers for the annual election of officers, address of the president and the reports of the various committees. The officers elected for the ensuing year were as follows: President, Walter S. Timmis, 315 Fifth Ave., New York City; first vice president, E. Vernon Hill, 704 City Hall, Chicago, Ill.; second vice president, Dr. Milton W. Franklin, 240 West Somerset St., Philadelphia, Penn.; treasurer, Homer Adams, 47 West 42nd St., New York City; Members of the Council: Howard H. Fielding, 618 Boston Bldg., Denver, Colo.; Harry E. Gerrish, 501 South Sixth St., Minneapolis, Minn.; George B. Nichols, Albany, N. Y.; Frank G. Phegley, 796 Rose Bldg., Cleveland, Ohio; Fred W. Powers, 5 South Wabash Ave., Chicago, Ill.; R. W. Pryor, Jr., 39 Cortlandt St., New York City; Champlain L. Riley, 101 Park Ave., New York City; F. R. Still, 1400 Russell St., Detroit, Mich.

The Tuesday evening session was the first in which professional papers were read and discussed. The first paper was by E. R. Hayhurst, M.D., of the Ohio State Department of Health, on "Experiments in Air-Conditioning in Houses." This was followed by "The Argument Concerning Mechanical and Natural Ventilation," by E. Vernon Hill, and "Air Washing and Humidification for School Buildings," by Perry West, chief engineer of the Newark, N. J., publi schools.

Commenting on the paper and the importance of ai washing, E. L. Hallett's remarks were much to the point He said: "The most important point in Mr. West's paper i emphasizing the necessity for publicity and popularizing o the subject of ventilation most needed at the present tim The public is not aware that it needs good, clean air t breathe. Today we use pure water to drink, but twent years ago purification of water was unheard of. Th Government inspects the food we eat and requires that i meet the pure-food regulations. Yet so far, there is one element that comes in contact with our bodies that hasn' been corrected, and that is the air we breathe. This is matter that I should like to see taken up by our Researc Bureau, and it is one of the most important subjects the could investigate."

The next session was Wednesday afternoon at 2 o'clock Papers on "Air Duct Design," by Leo Kraft, "Arrangemen of Heating Pipes an Important Factor in the Decay of Factory Roofs," by F. J. Hoxie, and "Dust Determination i Air and Gases," by E. R. Knowles, with their discussion occupied the time. The evening session Wednesday wa opened with a topical discussion on clean-out openings i heating boilers. James A. Donnelly urged standard specifications requiring two 2-in. openings in the lower part o each boiler and the installation of a surface blower. H said in part: "A boiler should be thoroughly cleaned befor it is first operated to get rid of the awful mess that accumulates there. I have found everything from carbon core mixture, to 6 in. of mud in the bottom of new boilers This should be washed out before the boiler is fired, and this can be best done by the use of plenty of hot water The code should provide for openings so that they can be cleaned out at the start and then there won't be any priming."

P. J. Dougherty said: "I agree with everything Mr. Donnelly has said. It is absolutely essential that boilers be eaned at the start if trouble is to be avoided later." The aring on the code for testing low-pressure heating boilers as then opened after Professor Allen had read the proposed de for 1919, which had been drafted by the committee, which Homer Addams was chairman. Frank K. Chew oved that the report as read by Professor Allen be ac- pted as the 1919 code. The motion was adopted by a animous vote for the first time in the history of the ciety on this subject.

Frank I. Cooper, chairman of the Committee on School- use Standards, reported very complete findings, with merous charts showing percentages of floor areas in hools all over the United States used for education, ad- nistration, heating and ventilating, and other purposes. e best school building in the country was designed, it as pointed out, to have 67 per cent. of the floor space de- ted to educational purposes. The worst school building point of educational facilities he found to be one of the rgest in New York City. From 3 to 12 per cent. is the erage floor space in school buildings given to heating and ntilating, Mr. Cooper found. C. B. J. Snyder, superin- ndent of buildings of the New York City Board of Edu- tion, expressed the opinion that 10 per cent. of the ace should be given to heating and ventilating. Chicago thorities say that 7 per cent. is sufficient. In many in- ances a surplus of space has been given to coal storage, e report showed, which tabulated 141 school plans in as any cities.

E. L. Hallett said: "I believe that too much space can- t be given for the storing of coal reserve, even if it rces the superintendent of the school out of office room. s superintendent of engineering in the St. Louis schools, have found it cheaper to deliver our entire winter's coal pply in the summertime than month by month. I have ved from fifty cents to a dollar a ton by such deliveries, you can see how much money can be saved by having equate space to store coal. I have also found that the ost unsatisfactory schools in our St. Louis system are ose where there has been crowding in the boiler rooms."

The Thursday morning session was opened by President ill reading a paper by F. A. De Boos on "Fuel Conserva- n by Means of Automatic Temperature Regulation," hich was then discussed, as follows:

H. L. Williams—There is need of seeing that the janitor school buildings has an interest in and understands how use the automatic control system to make it effective.

C. R. Bradbury— In one of Washington's Government ildings steam is purchased but the occupants are in the bit of opening the window rather than shutting off the diator. This makes clear the need of wider use of auto- tic control.

Perry West—I am positively in favor of automatic con- l, but there is need of a better understanding of the use d value of such service.

F. R. Still—In this work the use of the wet-bulb ther- meter for taking temperature should become general. wet-bulb temperature kept right will enable the dry-bulb nperature to vary 8 deg. without complaint.

The report of the Committee on Automatic Heat Control Chairman Samuel R. Lewis was then read and discussed, llowed by a paper by John R. Allen on "A Test of the nductivity of Window Shades." Discussion was then ken up of the topic "Capacities of Automatic Roof Ven- ators."

The final session, on Thursday afternoon, was opened th the reading of Konrad Meier's paper on "Limiting the el for Domestic Heating," by the secretary, by abstract. the paper was written last August, before the armistice as signed, it was more timely then in that it offered ideas the solution of problems arising from war conditions. erage coal consumption is computed per 1000 cu.ft. of ace. Records are given covering a large number of Amer- n residences which give a requirement of approximately 5 t.u. per cu.ft. of heated space for city residence, 6 B.t.u. suburban brick houses and 7 B.t.u. for frame houses. ve causes of waste are shown, all of which, it is ex- ained, may be avoided to some extent. Construction can improved, ventilation can be shut off where not needed, boiler efficiency can be raised, the application of heat can be brought more into harmony with the needs, are some of the suggestions made.

John R. Allen said: "There is a distinct difference in localities as to the amount of fuel needed. Now, in Minneapolis we burn less coal with the temperature at 30 deg. below zero than they do in Detroit, where the climate is less severe, and we use smaller heating units, too. The reason for this is that in my part of the country every house has a 'winter overcoat,' and has proper insulation to hold heat."

The paper that followed considered another phase of the same topic and advanced the theory that in fuel consumption weather control over heating is a most important factor. The subject was "Engineering Economics of Heating," and was presented by M. William Ehrlich, of New York, (published in *Power*, Feb. 12 and Mar. 5, 1918.) Many figures were presented, representing actual conditions in cities all over the country, in the development of the theory. While the human element modifies the results somewhat, control over heating is the most important factor, it is explained. Combining the two, all figures are at once placed on an empirical basis and the coal consumption is determined by this new condition. Formulating this theory gives a method for predetermining the coal requirements, which in turn becomes a standard for measuring the relative fuel economy of any heating plant. The new theory, it is asserted by the author, proves that it is not fair to relate coal consumption to cubic contents of the building heated, nor does a relation of coal consumption to installed heating surface give conclusive results.

The last paper was on "Byproduct Coke," by William T. Hannes, of Detroit.

The Entertainment Committee acquitted itself with credit throughout, the closing event being the annual dinner-dance, held at the Hotel McAlpin, which was well attended and thoroughly enjoyed. Following Toastmaster Still and a speech by President Timmis, Mr. Staples, of Buffalo, made a speech and W. F. Wetmore entertained with recitations, both receiving hearty applause.

Annual Meeting Indiana Engineering Society

During its thirty-ninth annual convention, held from Jan. 23 to 25 at Indianapolis, the Indiana Engineering Society devoted an entire session to the discussion of power-plant subjects. A. R. Holliday, Federal fuel administrator for the state, spoke of the phenomenal rise in the price of fuel in Indiana. Screenings that had formerly cost 90c. per ton rose to $5 per ton. In 1915 seventeen million tons were mined, and in the next three years the figures jumped to nineteen, twenty-four and thirty million tons respectively, the rate in October, 1918, being thirty-six million tons. The speaker described the general work of the Fuel Administration and indicated that in Indiana it had been so successful in its campaign of education that there was enough coal on hand in the fall to take care of any kind of a winter even though the mines shut down, and that now there was such a supply on hand that the mines could remain inoperative for 20 days without anyone suffering.

Prof. Frank C. Wagner, of Rose Polytechnic Institute, presented a paper on fuel conservation in the steam plants of Indiana, with special reference to the grading of the plants from the questionnaires sent out by the Fuel Administration. For most of the first-class plants the rating averaged about 75 per cent. Throughout the state 600 plants were graded; 483 of these were power plants, the others being used for heating only. Of these 483 plants, aggregating 287,884 hp., 38.6 per cent. reported that they had made improvements or would shortly do so; 93 per cent. reported no defects in boiler settings, although the speaker explained that many took the occasion to plaster up the holes before the reports were made. Feed-water heaters were used in 77 per cent. of the plants; 57.2 per cent. weighed the coal, 12 per cent. measured the feed water, 12½ per cent. had draft gages, and 10 per cent. had CO_2 apparatus. The average marking was 70.13 per cent.

Nine plants had a rating of 95 per cent. and better, and 16 plants were graded between 90 and 95 per cent. The principal advantage accruing from the campaign was in the education that certain economical operating conditions must exist, and that complete operating records must be available before any great improvements in economy could be expected.

George W. Hubley, administrative engineer for Kentucky, gave the following figures for that state: Of 1199 questionnaires sent out to the plants in the state, 557 were returned. Nineteen plants were rated between 81 and 93 per cent.; 314 between 61 and 80 per cent.; 198 between 41 and 60 per cent.; 26 between 23 and 40 per cent.; the average for the state was 62.1 per cent. Referring to the 557 plants, 57.3 per cent. weighed the coal, 7.3 per cent. metered the feed water, 76.9 per cent. had feed-water heaters, 11.9 per cent. had draft gages, and 5.5 per cent. used CO_2 apparatus.

PUBLIC UTILITIES IN THE WAR PERIOD

H. O. Garman, chief engineer of the Indiana Public Service Commission, read a paper on "Public Utilities in the War Period." He said that the making of large quantities of munitions within the borders of the state had resulted in an unprecedented demand on the power stations of the public utilities. Before the war period the power consumers of electricity had succeeded in reducing the power rates to but little more than the switchboard costs, and the largest one item of cost was coal. Coal costs jumped from $1.25 and $1.50 per ton to $3.50 and $5. The coal cost per kilowatt-hour ran from 0.35 to 0.75c. before the war, and during the war it ran up to 1 to 3c., and in some cases of bad management and poor maintenance to as much as 4c. per kilowatt-hour, the coal consumption ranging from 17 lb. downward to 3½ lb. of coal per kilowatt-hour. To overcome the increased cost of production the commission had arranged for surcharges for electrical energy based on cents per kilowatt-hour, and not per cent., for the reason that the large increase in cost of electrical energy was caused by the unprecedented rise in the cost of coal, and coal did not enter into the various rates with an equal percentage. For example, assume a coal cost of 0.5c. per kw.-hr., a power rate of 1c. per kw.-hr. and a lighting rate of 10c. per kw.-hr. If the coal cost doubled, then there would be added 0.5c. per kw.-hr. to each of the rates, or the new power rates would be 1.5c., an increase of 50 per cent., and the new lighting rate would be 10.5c., or an increase of only 5 per cent. Power rates are always competitive rates, for utilities must bid against the cost of power in the isolated plants. The potential competitive element is always a factor in power rates, but on account of the higher cost of labor, prime movers and coal, the competitive potential has been raised so that power rates will never settle back to their original datum, or level, although they will settle back some from the present abnormally high costs.

HEATING PLANTS PROFITLESS

Central-station heating plants were sorely pressed, both hot-water and steam plants; many of them would have abandoned the service entirely if the commission would have permitted it, and if it could have been done without causing suffering to their patrons. None of the 37 heating plants in Indiana made a fair return on its value, and by agreement three of them have abandoned service permanently.

On account of incompetent management of many of these heating plants, comparatively large investments and extravagance of consumers, it costs about twice as much to heat a dwelling from a central station as it would to heat it independently. During the last year the commission in coördination with the United States Bureau of Standards has developed and adopted a set of standards for central-station hot-water heating, which, together with close commission supervision, is probably responsible for saving many of the Indiana heating plants from the junk heap.

Next to the heating plants the gas plants were sorely pressed by a shortage of labor, zoning out of coal, poor gas-coal substitutes, high prices and poor management. Water-supply utilities suffered only the usual war increase in cost of purification materials, coal and labor, and whe normal prices are restored again they will be back nearl to a pre-war basis. New economic conditions are facin the street railways and interurban railways, and the safet of the investments is being seriously impaired. Telephon utilities have suffered the least of all, due to war conditions

In conclusion it was observed that the public utilitie situation is clearing up immensely compared with what appeared to be the outlook one year ago. Standards of servic will be much better maintained in the immediate future and when the price of coal is reduced, the abolition of th war surcharges may be anticipated.

The following officers were elected for the ensuing year Prof. G. A. Young, president; Charles Cheney, vice president; Charles Brossman, secretary-treasurer.

Midwinter Convention, A. I. E. E.

The American Institute of Electrical Engineers will hol its seventh annual midwinter convention, Feb. 19-21, 1919 in the Engineering Societies Building, 33 West 39th St. New York City. The convention will open Wednesday afternoon in joint session with the American Institute of Mining Engineers, at which five papers on electric welding will be presented: "Microstructure of Iron Deposited by Electric Arc Welding," by G. F. Comstock; "Path of Rupture in Steel Fusion Welds," by S. W. Miller; "Welding Mild Steel," by H. M. Hobart; "Electric Welding in Shipbuilding," by S. V. Goodall; and "Fusion in Arc Welding," by O. H. Eschholz. Wednesday evening will be devoted to a lecture by Dr. John A. Brashear, on "An Evening with the New Astronomy," which will be followed by an exhibition of technical moving pictures as adopted by the United States War Department for the instruction of the Army in the operation of various mechanical devices.

On Thursday morning there will be a technical session opened by an address by President C. A. Adams, followed by the presentation of two papers: "The General Equation of the Electric Circuit—III," by C. P. Steinmetz; and "Review of Work of Subcommittee on Wave-Shape Standard, of the Standards Committee," by H. S. Osborne. Thursday afternoon will be devoted to a technical excursion to the Brooklyn Navy Yard. Opportunities to visit the prominent electrical plants in New York and vicinity during the time of the convention have also been provided. On Thursday evening there will be a dinner-dance at the Hotel Astor for members and guests in attendance at the convention.

Friday morning's technical session is under the auspices of the Electrophysics Committee and papers will be presented on: "Ionization of Occluded Gases in High-Tension Insulation," by G. B. Shanklin and J. J. Matson; "The Dielectric Strength of Air Films Entrapped in Solid Insulation," by F. Dubsky; and "Abnormal Voltages in Transformers," by L. F. Blume and A. J. Boyajian. On Friday afternoon the final session of the convention will be held under the auspices of the Telegraphy and Telephony Committee, at which the following papers will be presented: "Aëro Telephony," by E. B. Craft and E. H. Colpitts; "Theory of Transient Oscillations," by John R. Carson; "Telephone Circuits with Zero Mutual Induction," by W. W. Crawford.

Petroleum oil as it issues from the well contains certain light fractions of the petrol and paraffin series, which it is not only desirable to extract from the crude by distillation, on account of their higher values, but which, if left in the crude oil and used as fuel would be a wasteful procedure, and further, would lower the flash point, which has been very properly fixed for fuel oil, says the *Engineer*, London, by British authorities, namely, Lloyds' Register of Shipping, 150 deg. F., British Admiralty, 175 deg. F., London County, 175 deg. F. The crude oil is therefore subjected to what is known as a "topping process," which is a distillation which cuts out those lighter fractions, leaving a product having a calorific value of about 19,000 B.t.u. per pound.

Progress in Turbine Ship Propulsion*

By FRANCIS HODGKINSON

Chief Engineer, Machine Department, Westinghouse Electric and Manufacturing Co.

THE high-speed turbine with the floating-frame reduction gear, invented by Admiral G. W. Melville and John H. Macalpine, has proved its reliability not only for use on land, but in marine service as well. The records of the Westinghouse Electric and Manufacturing Co. show that between November, 1915, and September, 1918, 31 ships using this equipment had been put into service and of these 23 have had no trouble with the propulsion machinery, 4 experienced some trouble due to improper lubrication, 2 to defective material, and 1 to errors in assembling the apparatus. None of these troubles was vital, and all were of a kind that might happen to any machine.

As large turbines are now being built which can deliver to the shaft about 80 per cent. of the energy theoretically available in the steam supplied to them, it is evident that further improvements in the turbine itself will not materially raise this efficiency. Therefore to improve the performance of the ship's power plant, a matter of importance in view of the rising cost of fuel, we must pay more attention to the auxiliaries and study the practice of the central-station engineer, who has been able to obtain excellent results in reducing power costs.

FEED-WATER HEATING SYSTEMS

A much-desired system is one that will automatically maintain a predetermined temperature in the feed-water heater at all times, bleeding from the main turbine when more heat is needed and permitting surplus steam from the auxiliaries not condensing in the heater to reënter the turbine and do useful work. Such heat-balance systems have been used on land for some time and should be developed for use at sea. Automatic valves that maintain the proper steam pressure and temperature balance are already available.

With the advent of turbine-driven auxiliaries and electrical winches, all the exhaust steam produced can be kept free from oil, so that the less expensive and more efficient open type of heater can be used in place of the standard marine tubular type.

Central-station engineers are today considering the use of steam at pressures as high as 600 lb. because of the higher operating efficiency thus secured.

Economizers do not appear to have been used on ships, but there seems to be no reason why they should not be applied on express steamers where they should permit a net gain of about 10 per cent. in fuel consumption.

Superheat has never been recommended in connection with the old slow speed direct-connected turbines, but superheats of as high as 100 deg. F. should present no difficulties with the high-speed geared marine turbine. This should save some 4 or 5 per cent. of fuel.

With a properly designed turbine the steam consumption will be 7 per cent. better with 29 in. of vacuum than with 28 in. The desirability of the use of such a vacuum is therefore obvious, but it can be obtained only when the most efficient condensing apparatus is used and when the greatest care is exercised to prevent air leakage.

IMPORTANCE OF THE OILING SYSTEM

The oiling system is vital to the proper operation of the turbine, and too much attention cannot be given to the layout of the system so as to insure an extreme degree of simplicity and reliability. In an ideal system the oil pumps should be placed at as low a level as possible; the drain tank should be large and thoroughly drain the turbines through large-sized pipes; the pump suction should be placed several inches above the bottom of the drain tank so as to avoid drawing dirty oil, but an auxiliary suction should be provided also that the tank can be completely emptied for cleaning; the pump should discharge through coolers into an overhead gravity tank located about 20 ft. above the machinery; duplicate coolers should be provided so as to permit either one to be cut out of service; the oil pressure in the coolers should be higher than the water pressure so that no water can mix with the oil in case of a leak; the overhead gravity tank should be supplied with a strainer and should contain a float-operated valve for controlling the speed of the oil pumps; and arrangements should be provided so that the presence of water in the oil can be immediately detected.

Cross-compound turbines, in which the steam regularly flows first through the high-pressure cylinder and then through the low-pressure cylinder, are essentially designed for vessels that always operate at their maximum speeds. Where cruising speeds are required, the divided-flow turbine is applicable. In this type all the steam passes through an impulse element in the high-pressure cylinder and then divides, one portion continuing through the high-pressure cylinder to the condenser and the other portion going through a separate low-pressure cylinder and then into the condenser. For cruising, the low-pressure cylinder can be cut out of service. This arrangement is also adaptable to constant-speed steamers. It will give nearly as good performance as the cross-compound type and has certain constructional advantages.

A modification of the divided-flow type is the series divided-flow turbine, in which certain of the turbine elements are operated in parallel for maximum speeds and in series for reduced speeds. This obviates the use of a separate cruising turbine.

SIMPLE TURBINE FOR PATROL BOATS AND CUTTERS

For patrol boats and cutters an exceedingly simple form of turbine has been designed. It consists of a single reentry impulse wheel with reversing buckets cut in the shrouds of the ahead blades, and with steam pressure of 330 lb. and 27 in. vacuum, the steam consumption by actual test is 14.9 lb. per shaft horsepower-hour at 600 hp.

It is frequent practice to provide two valves, one for ahead and the other for astern, but as this arrangement is somewhat inconvenient and permits both valves to be opened at the same time, the Westinghouse company prefers to provide a single valve which controls the steam in both directions and is more easily manipulated.

There is much difference of opinion as to the relative merits of the electric and the geared turbine drive. Electric drive is being installed on certain battleships, and while its operating success is certain, the question as to whether the increased complications, increased cost and weight of machinery, and increased steam consumption per propeller horsepower are warranted, can only be answered by future developments.

One system of electric drive has been proposed which has promise of excellent economy. This consists of the use of a number of small Diesel engines, with cylinders not greater than ten inches in diameter and therefore well within the limits of reliability, each of which is to drive a small generator. These units can of course be located anywhere in the ship.

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*Abstract of paper read before the Society of Naval Architects and Marine Engineers, Philadelphia, 1918.

Information and Education Service, Department of Labor

The Working Conditions Service, Department of Labor, announces in connection with its plans for safety work during the coming year that the following codes will be first taken up, with the coöperation of the Bureau of Standards, Department of Commerce:

Plant arrangement, including routing of material and product, design of buildings and layout of plant; yard entrance and exit gates, roadways and walkways, railroad tracks, material piles, clearances and illuminations; fire hazards, including fire-fighting equipment, water mains and hydrants, spacing between buildings as related to occupancy, and arrangement of yard material as related to occupancy of buildings.

Building equipment, including stairs and exits, skylights, ladders, railings, and toeboards (fixed), platforms and scaffoldings (fixed), illumination and window cleaning.

Fire prevention and protection.

Elevators, including shaftways and hatchways, shaftway equipment, cables, counterweights, guide rails and bumpers, landings, landing doors and gates, cars and car construction, machines, machinery and machine rooms, car and machine safety devices, control and signals, and escalators.

Cranes and derricks, including controllers and wiring, hoist mechanism and brakes, clearances, bridge, tower and gantry cranes, locomotive cranes and derricks, and hand-power cranes.

Conveyors and conveying machinery.

Steam engines and turbines, including piping and valves, overspeed devices and governors, safety valves and guarding.

Hydraulic machinery, including piping and valves, overspeed devices and governors, safety valves and guarding.

Oil and gas engines, including piping and valves, overspeed devices and governors, safety valves and guarding.

Mechanical transmission of power, including shafting and bearing, shifters, shippers and belt fastenings, gears, clutches and friction devices and control of power.

Head and eye protection, including protectors for chippers, riveters, calkers, babbitting and similar operations, sealing, grinding and similar operation, dipping and brush coatings, sandblasting, oxyacetylene welding and furnace work, and electric-arc welding and cutting.

Lumber and wood-working machinery.

Textile machinery.

General chemicals, including acids, anilines and coal-tar derivatives, caustic alkalies, gases now not used for power production, oxidizing materials, phosphorus and matches and alcohols.

Explosives.

Rubber and composition goods.

Proposed Engineers' License Law for West Virginia

A bill has been introduced in the West Virginia Senate by Senator Luther, of McDowell County, requiring the licensing of stationary engineers. The measure in brief provides:

That it shall be unlawful for any person to operate a steam boiler or engine in the State of West Virginia of more than 50 hp., except locomotive boilers and engines, and other boilers and engines under the jurisdiction of the United States Government, without having been duly licensed so to do, as herein provided. And it shall be unlawful for any owner or user of any steam boiler or engine, other than those excepted, to operate or cause to be operated, such steam boiler or engine without a duly licensed person in charge.

The office of the chief examiner of engineers is created. The Labor Commissioner shall appoint as chief examiner with the approval of the Senate some citizen of the state entitled to vote, who has had not less than ten years' experience as a practical steam engineer and whose term of office shall begin May 1, 1919, and shall continue for four years and until his successor has been appointed and qualified, unless he is sooner removed. He shall give bond, with good security, to be approved by the Governor, in the penalty of $3000, for the faithful performance of all his duties and for accounting for and paying over, as required by law, all money which may come into his hands by virture of said office, and such bond shall be filed in the office of the Secretary of State. The Labor Commissioner may remove such officer in case of incompetence, neglect of duty, gross immorality or malfeasance in office, and in case of a vacancy, whether occurring by removal or otherwise, may declare the office vacant and fill the same by appointment for the unexpired term.

The Labor Commissioner of the State of West Virginia, together with the chief examiner of engineers, shall divide the state into three examination districts. The chief examiner shall appoint an examiner for three districts outside of that occupied by the chief engineer, who shall have had five years' practical experience in the operation of steam engines and boilers and whose bond shall be in the sum of $2000. The said district examiner shall receive a salary of $2000 per year and not to exceed $1200 for traveling expenses while in the discharge of his official duties, which shall be paid by the auditor from funds appropriated for that purpose, upon receipt of a properly certified expense account.

Any person who desires to act as a steam engineer or fireman shall make application in the district in which he resides, to the district examiner of steam engines for a license so to act, upon a blank furnished by the examiner, and shall pass an examination on the following subjects: The construction and operation of steam boilers, steam engines and steam pumps, under such rules and regulations as may be adopted by the chief examiner.

Any person to whom a license is issued under the provissions of the act, shall, at the expiration of one year from the date thereof, be entitled to a renewal thereof for one year unless, in the opinion of the district examiner of his district the person shall have the right to appeal to the chief examiner provided for in Section 8.

It shall be the duty of each examiner to notify every person operating a boiler or engine in his district mentioned in Section 1 and not included in the exceptions therein specified, to apply for a license under the act within sixty days and give such persons a reasonable opportunity to take the examination therefor.

Any owner or user of boilers or engines, or any engineer or fireman who after being notified as provided in Section 9 of the act, violates any of the provisions of the act, shall be fined not more than $50 and not less than $25. The examiners shall have the authority, and are hereby empowered to visit any and all engine rooms or boiler rooms in the state at all reasonable hours, for the purpose of seeing whether unlicensed persons are operating steam engines or boilers.

New Airplane Engine

The Liberty engine, which is of the multicylinder V-type, weighs, in the 400-hp. size, over 2.7 lb. per hp., with accessories and including cooling water and radiator. A new engine now being developed by John W. Smith, of Philadelphia, is expected to deliver the same horsepower. It has ten cylinders 5½-in. bore by 6½-in. stroke, and an estimated weight of but 1.3 lb. per hp. A British engine with nine of these cylinders is said to develop 310 hp. and weigh 640 lb., or 2.06 lb. per horsepower.

The new engine is of the fixed radial cylinder type, air-cooled. At the recent convention of the Society of Automotive Engineers, Mr. Smith gave out many interesting details concerning his experimental work in developing the engine. He believes that the air-cooled engine will soon displace the water-cooled types, for aëronautic use.

During the first two years of the war, Mr. Smith explained, he was in England conducting experiments on fixed radial air-cooled engines for the British government. Two designs were perfected, and both have seen actual service. Official British reports regarding the ten-cylinder engine credit it with a fuel consumption of less than 0.50 lb. of gasoline per b.hp.-hr. and a lubricating-oil consumption of less than 0.02 lb. per b.hp.-hr., while the nine-cylinder engine is reported to use less than 0.45 lb. of fuel per b.hp.-hr. These figures indicate a remarkably high economy of operation.

There is a real necessity that the future responsible chief should shoulder responsibility without definite guidance at an early age. It may be said that few engineers begin their life work until thirty; the previous years are those of training, education, experience and guidance. The next decade establishes results and furnishes proof of ability under the increasing load. If at 50 the individual is not in responsible charge, it is safe to assume he will never get much further. Accumulation of knowledge is most rapid in the earlier years, but time is required for stability and balance, and responsibility accelerates these indispensable qualities. No one has ever finished learning until decay supervenes; in the school of experience we are all pupils. Some at 20 know virtually all they will ever acquire, subsequent experience is a permutation of the knowledge gained; in other cases atrophy of intellect is deferred to extreme old age.

Bituminous-Coal Production in 1918

All records of bituminous-coal production in the United tates went by the boards during the year just closed, acording to a statement issued by the National Coal Assoation Jan. 1. Official figures of the United States Geogical Survey, supplemented by a conservative estimate the National Coal Association for that portion of the ear not yet recorded by the Government, place total biminous-coal production in 1918 at 587,500,000 tons, an crease of approximately 36,000,000 tons, or nearly 7 per nt., over production in 1917, in itself a record.

The nation's war-time demand for coal, the heaviest in e country's history, has been met in full. The mining this banner tonnage during 1918 also virtually insures e country against a repetition of the distressing shortage bituminous coal experienced last winter. With fair opating conditions and intelligent distribution of the product, it is likely that there will be sufficient bituminous coal for the nation during the winter.

The year's record tonnage has been mined, under the spur of war-time necessity, with fewer men, generally, in the coal mines of the country than during 1917, when the output was materially lower. Increased efficiency of management, the patriotic desire of operators and employees to support the Government in prosecuting the war to the maximum of their ability, and a better car supply and movement under the operation of the United States Railroad Administration, are chiefly responsible for the increase in production.

A year ago the country faced an unprecedented coal shortage; today it faces the prospect of a sufficient bituminous-coal supply to meet its requirements. The change has been brought about by a year of the utmost activity, vigorous action and close coöperation with the United States Fuel Administration.

Personals

J. Paul Clayton, who has been associated th the Middle West Utilities Co., at icago, has been elected a vice-president the Central Illinois Public Service Co., d has moved to Mattoon, Ill.

George H. Sharpe, who until recently as fuel engineer for the conservation dertment of the United States Fuel Adnistration, has become associated with ame, Friend & Stineman, Inc., at New aven, Conn.

Herbert B. Reynolds, formerly a fuel gineer in the United States Bureau of nes, has returned to the motive-power partment of the Interborough Rapid ansit Co., New York City, as mechanical search engineer.

Melvin B. Newcomb, formerly chief aftsman of the hydraulic department of Wellman-Seaver-Morgan Co., Cleveland, io, has been appointed chief engineer the rubber machinery department at the ron works of the same company.

Engineering Affairs

The New England Water-Works Assotion will hold a meeting at the Hotel unswick, Copley Square, Boston, Mass., Feb. 12.

The American Society of Mechanical gineers is to hold an organization din-meeting of the engineers in Havana, ba, on Feb. 22.

The San Francisco Section of the A. M. E. will hold a meeting at the Eneers' Club on Feb. 13. The subject will on "The Present Status of Electrical Welding," by F. A. Anderson, electrical pector of the United States Shipping ard.

Miscellaneous News

The Westinghouse Electric and Manuturing Co. has completed and opened the ssington Club" for the exclusive comfort, venience and entertainment of its emyees at the Essington Works, South iladelphia, Penn. The equipment of the ablishment is of the most modern and operation of the club is in charge of special management. It is one of the gest places of its kind in the Delaware ustrial section.

Martinsburg Power System—With the ing-in" of the new transmission line n. 12 from the recently completed genting station at Dam No. 5, on the tomac river, to the substation located the Potomac Light and Power Co.'s am plant, at Martinsburg the last link the improved power system for Martinsg, W. Va., was forged. This link comtes the chain that connects the steam nt at Security, Md., and the hydro plant Dam No. 5, with the steam plant at rtinsburg and the hydro plant at Dam 4. The line and plant construction has ailed the expenditure of vast sums of ney and was built with the sole purpose furnishing the City of Martinsburg and immediate vicinity with the best elec service obtainable.

Business Items

Warren Webster & Co. announce the opening of an office at 805 Sumpter Building, Dallas, Tex., with W. B. Irwin in charge as district representative.

Butler and Hayes, Inc., have opened an office at 220 Devonshire St., Boston, Mass., as mechanical and chemical consultants and experimental engineers; and their testing laboratories are fully equipped for the study of industrial problems.

The American Bosch Magneto Corporation is the official name of the former Bosch Magneto Co., which was recently sold by the Alien Property Custodian of the United States to the highest bidder. The entire holdings and organization, including the Bosch works at Springfield, Mass., have been taken over and the large output will now be devoted entirely to the requirements of American manufacturers and the public.

The American Pipe Bending Machine Co., of Boston, is about to open up pipe-bending plants in all large cities throughout the country. The first plant is about ready for operation at Lowell, Mass. The company will make a specialty of furnishing bent pipe and make delivery of small orders in forty-eight hours notice. Each plant will have facilities for turning out from 1000 to 3000 bends per day, and will be in charge of an expert pipe bender.

Trade Catalogs

The Expanded Metal Engineering Co., of New York City, has recently issued a 40-page illustrated booklet entitled "Steelcrete Machine Guards," which contains much useful information regarding specifications and machine guard requirements for anyone desirous of installing machine guards. A copy of the booklet may be had upon request.

New Construction

PROPOSED WORK

Me., Portland—The Russell Shipbuilding Co. will rebuild its boiler plant and saw mill, recently destroyed by fire. Estimated cost, $25,000.

Mass., Belchertown—The Commonwealth of Massachusetts will install a steam heating system in the 2-story, 75 x 90 ft. dormitory which it plans to build at the Home for the Feeble-Minded here. Total estimated cost, $100,000. Address G. M. Kline, 36 State House, Boston, Dir. of Mental Diseases. Kendall, Taylor & Co., 94 Federal St., Boston, Arch.

Mass., New Bedford—H. T. Borden, Chn. of the Hospital Comn., 154 Fair St., will receive bids in the spring for the construction of a power house, laundry, etc., in connection with the group of hospital buildings which will be constructed on Mt Pleasant, Myrtle, Van Buren and Jefferson St. Total estimated cost, $100,000. J. R Worcester & Co., 79 Milk St., Boston, Engr.

Mass., Rutland—The Central New England Sanitorium will build a 3-story, 40 x 90 ft. administration building and two 3-story, 35 x 100 ft. ward buildings. A steam-heating system will be installed in same. Total estimated cost, $250,000. B. T. Crane, Supt. E. F. Stercus, 9 Park St., Boston, Arch.

Conn., Hartford—The Johnson & Webster Co., 327 Trumbull St., will install a steam heating system in the 6-story, 40 x 126 ft. apartment hotel which it plans to build on Washington and Park St. Total estimated cost, $160,000. Russell F. Barker, 43 Ann St., Arch.

N. Y., Forest Hills—The Board of Education, 500 Park Ave., New York City, will install a steam heating system in the 2-story, 105 x 108 ft. public school building which it plans to construct here. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., New York City, Arch.

N. Y., New York—The Board of Education, 500 Fifth Ave., will install a steam heating system in the 5-story, 60 x 142 ft. public school building which it plans to build on Tremont and Bryant Ave., Bronx Borough. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., Arch.

N. Y., New York—The Board of Education, 500 Fifth Ave., will install a steam heating system in the 5-story, 118 x 192 ft. public school building, which it plans to build on Crotona Ave. and 181st St., Bronx Borough. Total estimated cost, $543,474. C. B. J. Snyder, Municipal Bldg., Arch.

N. Y., New York—B. F. Keith, 1564 Broadway, will install a steam heating system in the 3-story, 200 x 228 ft. theatre which he plans to build on Fordham Rd. and Valentine Ave., Bronx Borough. Total estimated cost, $300,000.

N. Y., Niagara Falls—The Hydraulic Power Co. has been authorized by the Public Service Commission to issue $2,000,000 bonds for extensions and improvements to its plant, to include the construction of an addition to power house No. 3, and the installation of new electric generating and hydraulic machinery. Noted Dec. 10.

Penn., Honesdale—The Honesdale Consolidated Heat, Light & Power Co. plans to build a 1-story electric power plant. Estimated cost, $50,000. F. H. Eisele, 110 Seventh St., Mgr.

Del., Wilmington—The Standard Kid Manufacturing Co., 4th and Monroe St., plans to build a 1-story, 40 x 60 ft., steam power plant. Estimated cost, $25,000. R. C. McMullen, Mgr., in charge. J. J. Kennedy, 925 Market St., Arch.

Md., Baltimore—The Western Maryland Dairy, 1125 Linden Ave., plans to build a 1-story, 49 x 74 ft. boiler house.

Md., Myersville — The Hagerstown & Frederick Railway Co., Terminal Bldg., Frederick, plans to rebuild its electric plant here, recently destroyed by fire. M. A. Poller, Frederick, Gen. Mgr.

Ga., Atlanta—The city plans to appropriate $70,000 for the construction of a generating plant. R. C. Turner, City Electrician.

Ga., Atlanta—The City Council plans an election March 5, to vote on $500,000 bond issue for improvements to the water-works, including installation of additional pumps. H. L. Collier, City Engr.

Ohio, Sandusky—David Olmstead, c/o H. L. Stevens, Arch., 910 South Michigan Ave., Chicago, Ill., will install steam heating system in the 6-story hotel which will be constructed here. Total estimated cost, $200,000.

Ohio, Toledo—The Toledo Railway & Light Co., Smith and Baker Bldg., plans to issue $3,500,000 bonds for the acquisition, construction, extension and equipping of additional property, also for improvements and extensions to the existing light and power plants. None of the money to be raised by these bonds is to be spent upon street railway property. F. R. Coates, Pres. and Gen. Mgr.

Ind., Gary—The Central Heating Co. plans to construct a large power house in connection with the heating plant which it will build on the high line railroad west of Broadway; first unit will be in operation by September. Estimated cost, $200,000.

Mich., Detroit—H. S. Starkey, Sec'y., Board of Commissioners, 232 Jefferson Ave., will receive bids until Feb. 10 for the construction of a 1-story, 54 x 90 ft. boiler house in the water-works park; boilers, monorail and beam in front of boilers, stokers and windbox will be installed in same.

Mich., Detroit—The Detroit Heat Treating Co., St. Paul and Bellevue St., will install electric motors in the 1 story, 13 x 55 ft. heat treating plant which it plans to build. Brown & Preston, 849-51 David Whitney Bldg., Arch.

Mich., Wyandotte—The city will receive bids until Feb. 18 for installing 2 pumps for immediate use (2 to be provided ultimately), 1 motor driven pump and 1 auxiliary motor and oil engine in connection with the improvements which it plans to the sewerage system in the western section of the city. Total estimated cost, $155,000. M. L. Brown & Co., 820 Chamber of Commerce, Detroit, Engr.

Ill., Aurora—The Trustees of the Second National Bank have awarded the contract for the construction of a 5-story bank building, to Hoggson Bros., 485 Fifth Ave., New York City, N. Y. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ill., Chicago—The Acme Malting Co., 175 West Jackson Blvd., has had plans prepared for the construction of a 1-story power plant at Cortland St. and Kilbourne Ave. Estimated cost, $15,000.

Ill., Streator—D. C. Murray, 309 East Main St., will install a steam heating system in the 5-story, 50 x 142 ft. store and office building which he plans to build. Total estimated cost, $175,000. G. C. Nimmons & Co., 120 South Michigan Ave., Chicago, Arch.

Wis., Jim Falls—The American Public Utilities Co., Grand Rapids Savings Bank Bldg., Grand Rapids, Mich., plans to build a power house and dam here. Estimated cost, $2,000,000.

Minn., St. Paul—The Northern Pacific Mutual Benefit Association, 203 Railroad Bldg., will receive bids in March for the construction of a 4-story hospital and power plant, on Simpson and Edwards St. Estimated cost, $300,000. L. Bassindale, 321 Capital Bank Bldg., Arch. Noted Nov. 5.

Minn., Tyler—The city plans a $20,000 bond issue for the construction of an electric-light plant and water-works system.

Kan., Hiawatha—The city plans an election soon to vote on a bond issue of $25,000 for improvements to the water-works system, to include the installation of pumps at the spring on the county farm, also extending the transmission line to the city system. J. B. Liebengood, City Clk.

Neb., Norfolk—The State Legislature, Lincoln, has been petitioned to appropriate $35,000 for building an addition to power house and smoke stack at the State Institution here.

S. D., Watertown—The city plans to build and operate an electric-light and power plant of sufficient size to take over the lighting of the streets and parks, run the pumping machinery of the water-works. Estimated cost, $250,000.

Wyo., Manville—The town has granted franchise to E. P. Bacon Casper, to build and operate a heating, lighting and power system here.

Wyo., Thermopolis—The town has adopted a resolution to make application to the Wyoming Public Service Commission for a transferable franchise to build a municipal light and power system. This action was taken in connection with an application to the Wyoming Public Service Commission by the Hot Springs Light & Power Co., for increase in rates, which was opposed by town on grounds of poor service.

Mo., Kansas City—The Kansas City Light & Power Co., 1500 Grand Ave., plans to improve its plant. Estimated cost, $5,500,000. Hugh Blackwell, Vice-Pres.

Mo., St. Louis—Jos. Greenspan's Son, 67 Branch St., is in the market for a 20 hp. oil engine.

Okla., Shawnee—The city plans an election soon to vote on a $500,000 bond issue for the construction of a modern light and power plant.

Okla., Yale—The city has had plans prepared for extensions to the light and water systems, to include improvements to the power plant, power lines, stack, switchboard, engine and boiler equipment. G. B. Gelder, City Clk.

Colo., Lamar—The City Council has applied to the Colorado Utilities Commission for authority to construct an electric-light plant. If permit is granted an election will be held this spring to authorize bonds for same. W. C. Fee, City Atty.

Wash., Spokane—The city plans to install a refrigerating plant in connection with the alterations it plans to the city market on Wall and Trent St. Estimated cost, $10,000. L. L. Rand, Arch., Rookery Bldg., preparing plans.

Cal., Brandy City—The Brandy City Mining Co. plans to build a power plant to supply electricity to operate the machinery in its mines. The company also plans to build a 150 ft. dam on the North Yuba River below Bullards Bar.

Cal., Sacramento—The city plans to build an electrically-operated pumping plant at the water-works. Thomas Coulter, Comn. Pub. Works.

Ont., Newmarket—The city plans to install special pumping apparatus, thereby increasing the existing water supply. James, Loudon & Hertzberg, Excelsior Life Bldg., Toronto, Consult. Engr.

Ont., Pembroke—The Town Clerk will receive bids until March 7 for furnishing and installing 1 water-works pumping unit, to consist of turbine pump of 2000 gallons capacity against 330 ft. head and a steam turbine or gasoline engine directly connected to pump.

CONTRACTS AWARDED

N. Y., Brooklyn—E. Riegelman, Borough President, has awarded the contract for reserving and furnishing electric generating capacity, etc., during the year, to the Edison Electric & Illuminating Co., Pearl St. Estimated cost, $47,400.

N. Y., New York—F. L. Dowling, Borough President, has awarded the contract for reserving and furnishing electric generating capacity for use of high pressure fire service pumping station for the year, to the New York Edison Co., 130 East 15th St. Estimated cost, $48,600.

N. Y., New York—The New York Academy of Medicine, 17 West 43rd St., has awarded the contract for the construction of a 6-story, 25 x 100 ft. addition to the college, to M. Eidlitz, 30 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $175,000.

N. Y., New York—Sperry & Hutchinson, 2 West 45th St., has awarded the contract for the construction of two 2-story, 105 x 200 ft. theatres on West 42nd St., between 7th and 8th Ave., to Thompson-Starrett Co., 49 Wall St. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. J., Jersey City—The Pennsylvania R. R., Broad St. Station, Philadelphia, Penn., has awarded the contract for recovering power, heating and vacuum lines from the power house at Washington St. to the depot on Exchange Pl., to the W. W. Farrier Co., 44 Montgomery St.

N. J., Newark—Peter Hauck, 85 Clifton Ave., has awarded the contract for installing power equipment in his factory, to W. G. Sharwell, 377 North 5th St. Noted Feb. 4.

Minn., St. Paul—The Northern Pacific Mutual Benefit Association, 203 Railroad Bldg., has awarded the contract for installing a heating and ventilating system in the 4-story hospital which it plans to build on Simpson and Edmund St., to Neiler, Rich & Co., 1407 Manhattan Ave., Chicago, Ill. Total estimated cost, $300,000.

Cal., Sacramento—The Northern California Milk Producers' Association, California Fruit Bldg., has awarded the contract for the construction of a plant, to include power house, cold-storage plant, etc., to the Clinton Construction Co., 357 Pine St., San Francisco. Total estimated cost, $125,000.

N. B., Marysville—The Nashwaak Pulp & Paper Co. has awarded the contract for the construction of a large dam to supply power for their new mill, to the Ambursen Hydraulic Construction Co., 10 Cathcart St., Montreal, Que.

THE COAL MARKET

BOSTON—Current quotations per gross to f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circula Curre
Buckwheat	$3.10	Boiler	$
Rice	2.90	Barley	

All rail to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Bosto $8.35 to $8.90.

NEW YORK—Current quotations per gro ton f.o.b. Tidewater at the lower ports* are a follows:

	Circular	Individual		Circular	Indi vid
Pea	$6.55	$7.30	Broken	$7.80	$8
Buck.	5.10	5.90	Egg	7.70	8
Rice	4.65	5.10	Stove	7.95	8
Barley	4.15	4.30	Chestnut	8.05	8

BITUMINOUS

Current quotations, gross tons, based on Gov ernment prices at the mines, net ton, f.o.b. Tidewater, at the lower ports, are as follow

	Mine Gross	F.O.B. N.Y Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.4
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.
Prepared	3.36	5
Slack	2.80	4.

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on a count of the difference in freight rates, and a exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Joh son, Port Reading, Perth Amboy and South A boy. The upper ports are: Port Liberty, Ho ken, Weehawken, Edgewater or Cliffside and G tenberg. St. George is in between and sometim a special boat rate is made. Some bitumin is shipped from Port Liberty. The rate to t upper ports is 5c. higher than to the lower por

PHILADELPHIA—Prices per gross ton f.o. cars at mines for line shipment and f.o.b. Po Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Y Ago
Pea	$4.80	$3.40	$6.05	$4.3
Barley	2.40	1.90	3.30	2.1
Buckwheat	3.40	2.90	4.45	3.5
Rice	2.90	2.40	3.80	3.4
Boiler	2.70	2.20	3.70	3.3

CHICAGO—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illino
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.30	2.75—2.90

BIRMINGHAM—Current prices per net t f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.1
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.
Climax seam near Maylene:			

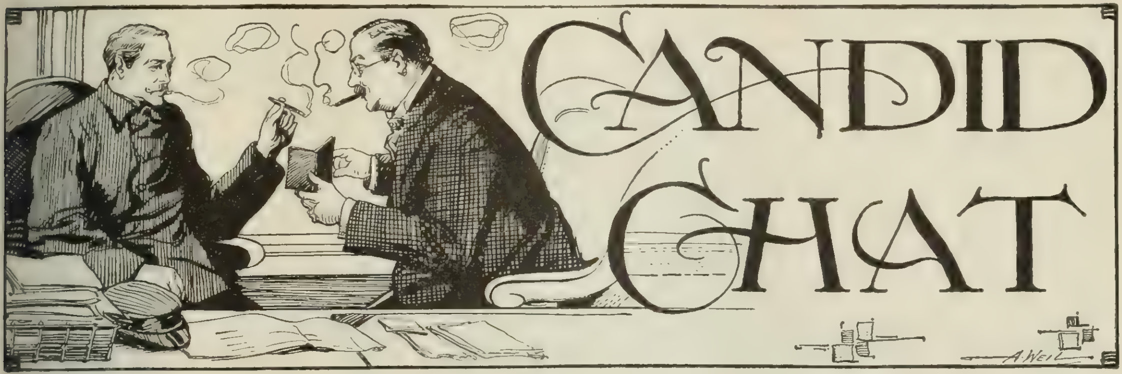
ST. LOUIS—Prices per net ton bitumino coal f.o.b. mine today as compared with a ye ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standar
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2
Mine-run	2.35@2.50	2.20@2.
Screenings	2.17@2.32	1.50@1

Williamson-Franklin rate to St. Louis is $1.1 other rates p. 95.

POWER

Volume 49 New York, February 18, 1919 Number 7



Osgood's Dope Book

When Anderson, our former chief, resigned to take charge of a new industrial plant that was nearing completion on the other side of the river, there naturally was a good bit of speculation as to who would succeed him. I confess that I was tickled when I got the message that Osgood, the manager, wanted to see me in his office.

There was little suspense. As soon as we had our cigars—Osgood's cigars, rather—going well, he quietly informed me that I had been chosen to fill Anderson's shoes. He didn't decorate his announcement with verbal bouquets. He was as matter-of-fact as though he were telling the butcher to cut off three pounds of steak.

I let him know that I was pleased, but I tried not to slop over in doing it. Then I asked him a point-blank question.

"If it isn't a state secret," I said, "I'd like to know just how you came to select me for this job."

"I don't mind telling you," he smiled.

From a pigeonhole he pulled out a notebook bound in red leather, opened it and held it out so that I could see my name at the top of one page, followed by many lines of fine writing.

"I call that my Dope Book," he remarked. "It contains a record of every man in the plant—his disposition, health, habits, strong and weak points, experience, training, home life and everything else that could possibly be of value in determining his fitness for advancement. It has helped me in selecting a good many men for promotion and I keep it more carefully than a schoolgirl does her diary."

I thanked him for the information and went back to my new job. But I couldn't help wondering whether other employers weren't following the same plan and whether many an engineer's failure to get ahead might not be due to certain unfavorable entries in somebody's unsuspected Dope Book.

Mechanical Equipment of a Modern Hotel

It is the purpose in two or three articles to describe the mechanical equipment of a modern hotel plant coming under the charge of the chief engineer and his operating staff. Nothing sensational or revolutionary is found, but taken as a whole it comprises a complete community service station probably with as diversified equipment as may be found anywhere. The reader who is not familiar with this branch of engineering may get an insight into the duties and responsibilities of his fellow engineer.

THE Hotel Pennsylvania, New York City, is the world's largest hostelry. It occupies a ground space 200 by 400 ft., is 19 stories above grade and contains 2200 guest rooms, a large number of living rooms for employees, business offices, dining rooms, grill room, roof garden, swimming pools, turkish baths, etc. The illustrations are for the most part from the actual contractors' blueprints loaned by courtesy of Messrs. Tenney and Ohmes, consulting engineers for the architects, McKim, Mead & White. Sizes or capacities are noted in many instances to add interest. At present there are no boilers in the building, although provision has been made for them if it is found desirable to put them in. Steam and electric power is supplied by contract from the Pennsylvania Railroad Co. Service station at 150 lb. gage pressure through either one or both of two pipe lines, one 12 and the other 8 in. in diameter. The condensate is returned to the boiler house by gravity through either of the return lines, one 5 in. and the other 3½ in. in diameter. The pipe lines follow approximately the plan shown in Fig. 1. The steam passes through separators located as shown in Fig. 2, which is near the point of junction of the Pennsylvania Railroad Co.'s service lines and those of the hotel. The course of the high-pressure steam lines within the building and the various cross-connections, reducing valves and supply branches may be traced on this plan. A careful study of the steam requirements was made based on the actual steam consumption in other hotels, extending over a period of years, so that it is probably the best-analyzed proposition of the day as to heat balance. As a result of this study it was found that much of the machinery could be steam-driven and the exhaust used for other purposes, thereby making the best possible use of the heat in the steam; and as a parting service, all of the condensate is put through a closed heater, in which it gives up more of its heat to the incoming cold water that is to be heated. It was found that during a large part of the heating season more low-pressure steam would be required than would be passed through the steam-driven ammonia and air compressors, pumps, etc.; therefore a 500-kw. direct-connected generator set has been put in, to be operated as much of the time as the exhaust from it can be utilized—the engine acting as a steam pressure-reducing valve, the generator supplying as much current as it may, to supplement the service from the service plant. The "heat balance" can in this way be kept almost ideal. There are numerous other steam units, including three horizontal steam-engine-driven double-vertical single-acting ammonia compressors. Each unit is rated at 90 tons' refrigeration. Two of the units operated at a time are expected to take care of the maximum demand, leaving one in reserve. Details of this and other power units will be taken up in connection with their respective sections. The major part of the heating is by direct radiation, of which there is approximately 100,000 sq. ft. of surface. To supply these radiators there are more than 100 pairs of risers (supply and return pipes), totaling about 15 miles of vertical risers and 12 miles of branch piping or radiator connections. The returns are under a moderate vacuum, each radiator having a thermostatic trap at the outlet and a modulated inlet valve. Indirect heating is employed in the roof restaurant. All exposed radiators are suspended on concealed wall brackets, and the pipe connections come through the wall and not the floor; so there is nothing to interfere with carpeting or cleaning. A typical radiator with connections is shown in Fig. 3. All steam risers are provided with expansion loops at the third and ninth floors to allow for expansion and contraction. These loops are made up of two 6- to 7-ft. lengths of pipe joined by two elbows, and a nipple or short piece of pipe. Fig. 4 shows a typical section of the heating risers, giving the pipe size and the amount of radiation supplied at each floor. In a few instances concealed radiators are located beneath the windows and consist of two separately piped sections, a little heat being allowed on the smaller radiator continuously in frosty weather to keep the window glass clear. Ventilation is accomplished by motor-driven fans, of which there are 9 now in place on the air sup-

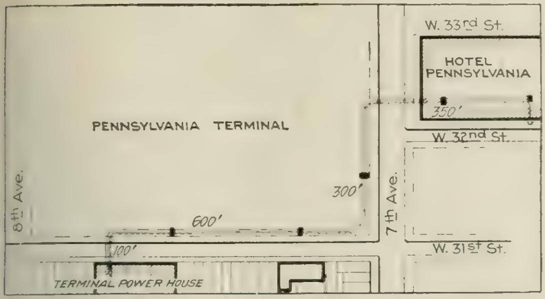


FIG. 1. APPROXIMATE RUN OF SERVICE LINES

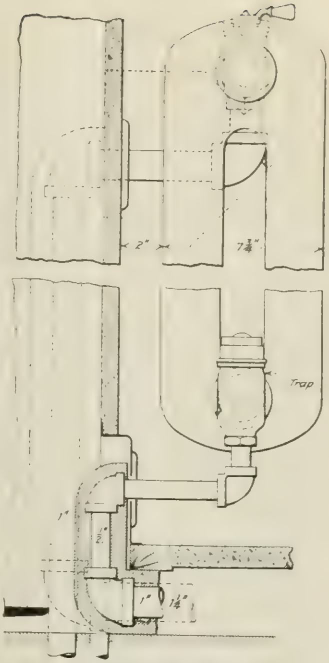


FIG. 3. TYPICAL RADIATOR CONNECTION

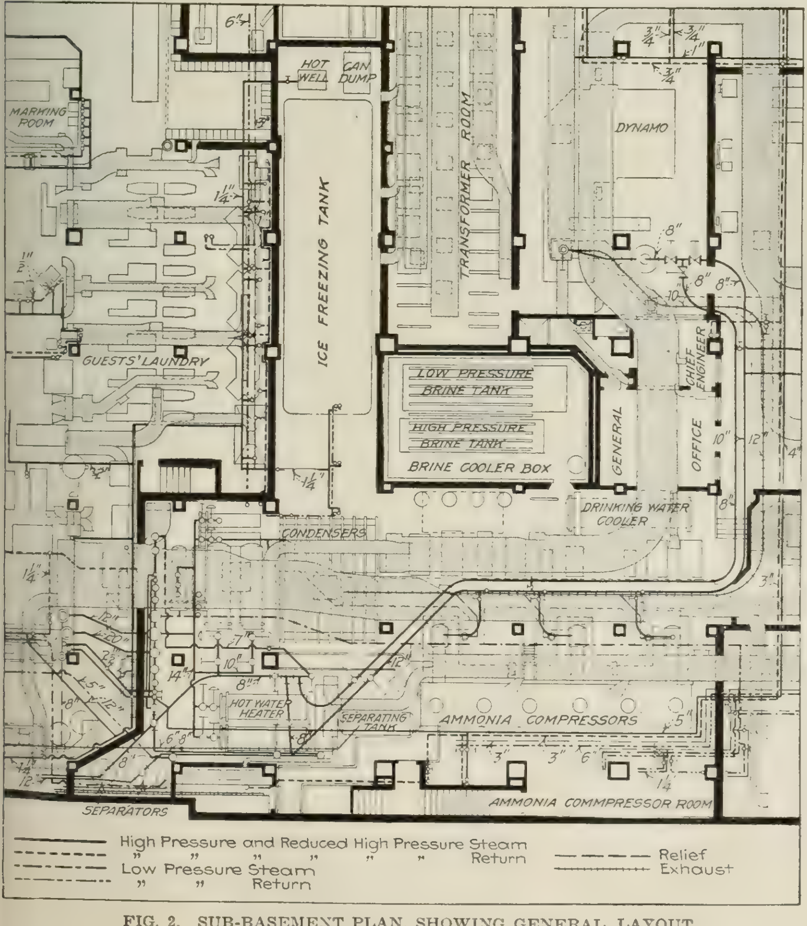


FIG. 2. SUB-BASEMENT PLAN, SHOWING GENERAL LAYOUT

ply and provision for 4 others later, and 16 exhaust fans now in, and ducts for 2 more if needed. There are 9 other fans in connection with the air washers, heat regulation, etc. The air-supply fan motors average about 25 hp. each, or a total of 227 hp.; the exhaust-fan motors about 27 hp. each, or a total of 428 hp. The grand total for the fan motors enumerated is no less

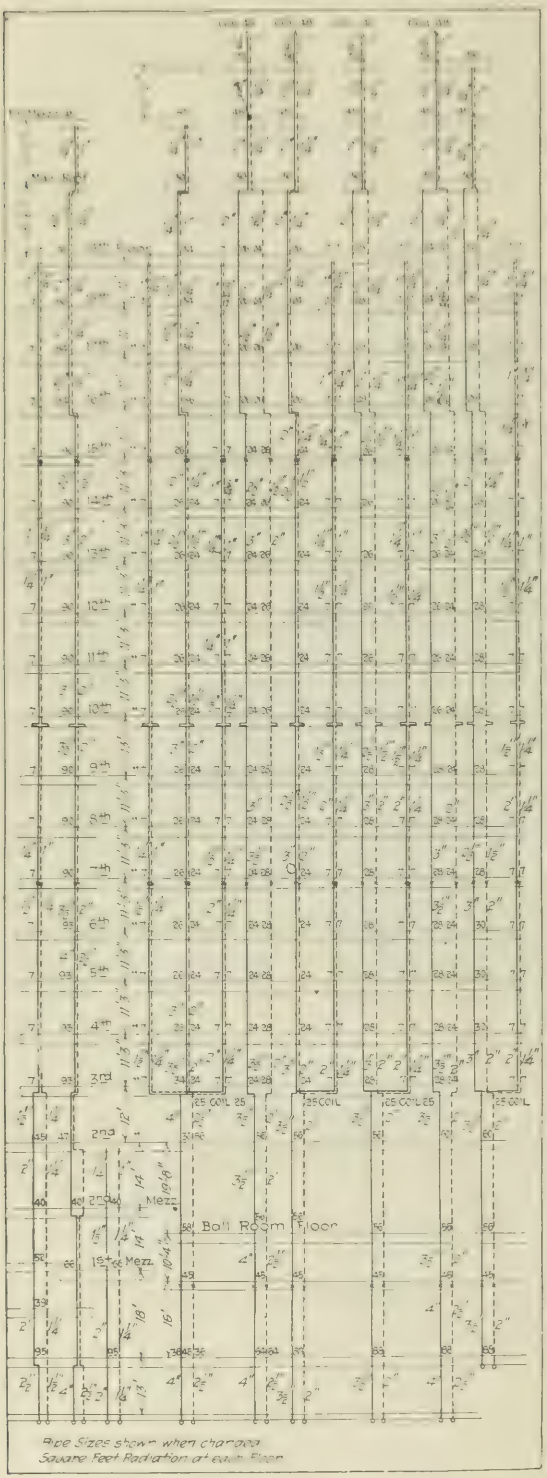


FIG. 4. SECTION OF RISER ELEVATION PLAN

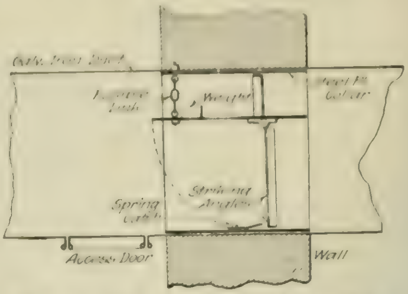


FIG. 5. SELF-CLOSING FIRE DAMPER

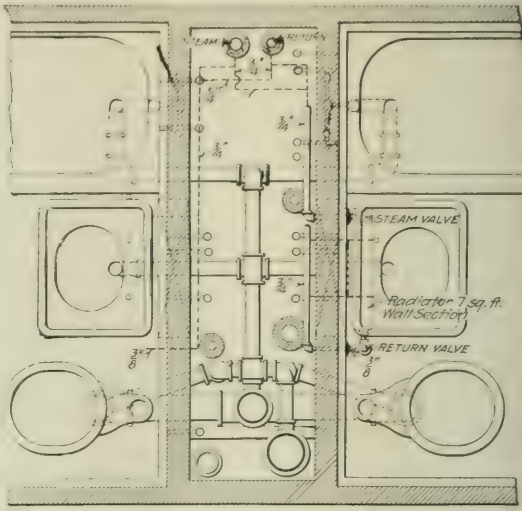


FIG. 6. PIPING IN SHAFTS BETWEEN BATHROOMS

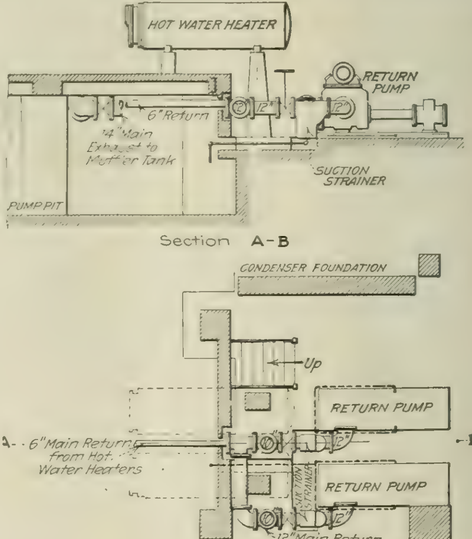


FIG. 7. RETURN-PUMP CONNECTIONS

than 700 hp. Outside air is taken in at the level of the third floor on the Thirty-third Street side of the building and is conducted downward to the air washers and fans through three ducts, totaling 300 sq.ft. area. The pipe shafts located between the bathrooms of adjoining rooms also serve as exhaust air ducts but vent ducts are kept free of all piping wherever possible with this exception. These shafts are approximately 2 by 7 ft. and contain the hot- and cold-water supply pipes, the refrigerated drinking-water pipe and the waste pipes from the bath tub, toilet and wash basin and the bathroom radiator piping, etc., as shown in Fig. 6. The register shown near the ceiling is for the bathroom ventilation. Each duct main register is, as required by the city fire regulations, fitted with a self-closing damper constructed as shown in Fig. 5, in which a fusible link that will melt at a low temperature is employed to hold the damper open normally; but in case of a slight increase in temperature, the link will fuse and allow the damper to close and prevent the spread of fire. A small door for entrance to the shaft is provided just above the wash basin. It will be observed by anyone who has had experience with pipe work that there is no great amount of excess room for workmen to make repairs when they become necessary. Many of the transfer spaces where piping, ducts, etc., are carried horizontally between the hung ceiling and the true ceiling present a surprising and intricate network of piping.

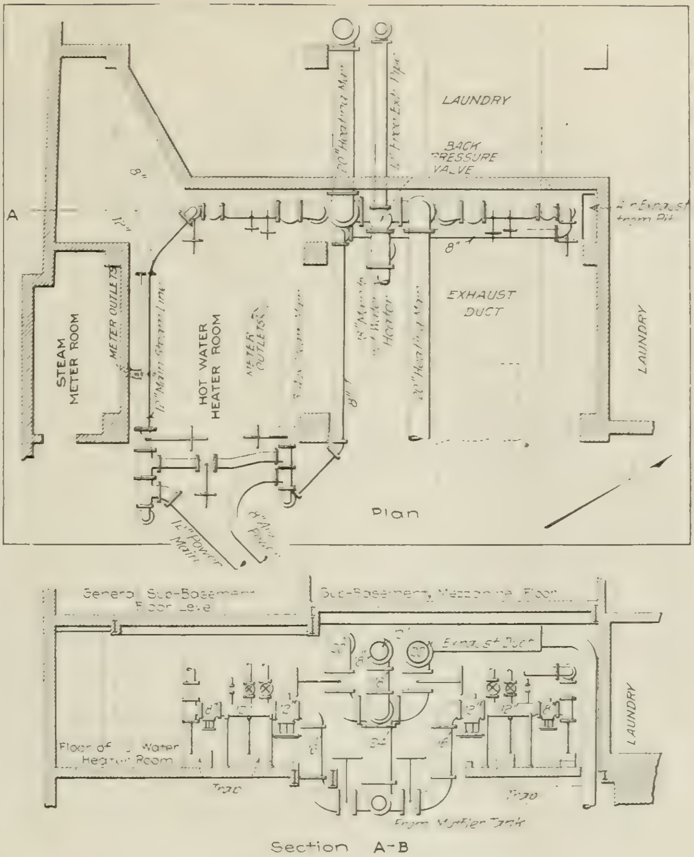


FIG. 8. PLAN AND ELEVATION OF PART OF HEATING MAINS

The returns from the heating system are connected to vacuum pumps in duplicate. The connections and pipe sizes are shown in Figs. 7 and 8. Fig. 9 is a floor plan of the fifth to fifteenth floors, those below being slightly modified by the dining and other large public rooms.

A section to follow will deal with the refrigerating plant and distributing piping and another with the electric and telephone systems.

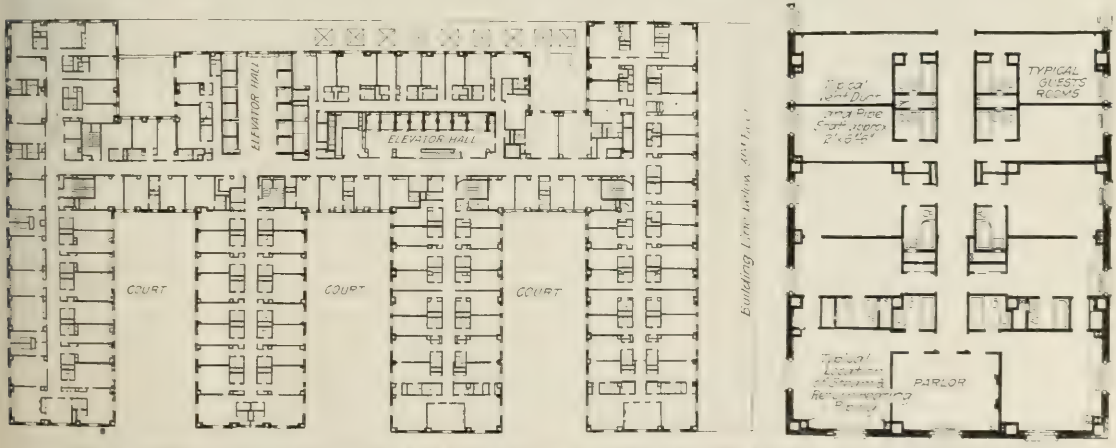


FIG. 9. TYPICAL PLAN AND ROOM ARRANGEMENT OF UPPER FLOORS OF THE HOTEL PENNSYLVANIA

Meeting Emergencies in Refrigerating Plants

By E. W. Miller

Vibration caused by a runaway engine allowed the gasket in the ammonia discharge line to blow out. If the men had abandoned the runaway because of the fumes, the engine and other machinery would have been demolished. The assistant engineer's quick wit saved the situation. With the day load coming on apace and only one small engine loaded, the voltmeter refused to register when the engineer was about to parallel the large unit. But he devised a means and "shot" the machine in without injury and in time to prevent blowing the circuit-breaker on the small unit. These and other situations, such as you have found yourself in, are told about by the author.

To hear some of the Old Timers talk, one would be held to believe that the days of rapid-fire thinking and the necessity for quick action were things of the past. In the good old days these fellows solved a half-dozen hair-raising problems in a day, and some of them evidently lay awake nights figuring out some new wrinkle to shut the plant down and make a record for rectifying the trouble. However, the youngsters of today might be able to show them a thing or two that would leave the veterans scratching their heads.

Not long ago in a large combined power and refrigerating plant the crew were having some trouble with the governor on one of the power engines, and it took the combined efforts of a man at the switchboard and an oiler at the throttle of the engine to keep the engine from racing or taking the entire load and eventually tripping the circuit-breaker and shutting down the plant. One of the assistant engineers was in the meantime trying to find out what was wrong with the governor and rectify it if possible.

A 200-ton Wolf ammonia compressor was running next to the contrary power unit. Between the two was a floor drain which had become plugged, and two men with a hose were trying to clear it by pumping into it water at a high pressure. Without warning, part of the gasket in a flange in the discharge line of the ammonia compressor, just above the floor, blew out. In a few moments the place would have been so filled with ammonia fumes that it would have been impossible to stay there, so everybody headed for the doors.

The Quick-Witted Assistant Engineer Saves the Day

The assistant, who was tinkering with the governor of the outlaw power engine took in the situation at a glance and realized that if left to itself the power would be off in a few seconds. Indeed one or more of the engines might be wrecked.

Yelling to the oiler and the man at the switchboard to stick to their places and watch the engine, he grabbed the hose, which had been abandoned the moment the gasket let go, and turned the full stream of water on the leak. At the same time he yelled to another oiler who was heading for the door to shut down the ammonia compressor.

Another man was sent pell mell up on the roof to shut off the valve in the discharge line at the condenser. The suction valve on the machine was shut before it stopped, the bypass valves were opened and the machine kept turning slowly until the head-pressure gage showed zero. This required but a few minutes, as the discharge check valve held nearly tight and a few revolutions of the machine pulled the gas out of the line up to this valve and brought the pressure down to atmospheric. In the meantime the stream of water directed at the leak absorbed much of the fumes. As soon as the pressure on the line came down to zero, a rag was tied around the leak and a stream of water kept gently playing over it. The bypass valve around the discharge check valve was slowly opened until the head-pressure gage showed a rise in pressure. In this manner the discharge line back to the condenser was pumped down to atmospheric pressure. When this was done the stream of water was shut off and the joint plastered with some boiler coating, after which a high vacuum was pumped on the line. This cleared it and allowed steamfitters to replace the gasket.

The quick-wittedness of the assistant in using the water hose to kill the ammonia fumes was probably all that saved the power equipment from demolition. The men stuck to their posts, and when the leak was stopped it was found that a piece of waste had got caught in the governor.

Voltmeter Refuses To Register

When getting ready to parallel a large power unit one morning, it was found that the voltmeter refused to register, when switched to this unit. The engineers lost considerable time trying to locate the trouble and finally discovered that one of the connections was broken. No wire was at hand to make a new connection, and besides it was in an awkward location where it would probably take half an hour to rig up even a temporary connection.

In a few minutes the load would be coming by leaps and bounds and the smaller unit, which was just able to take care of the regular night load, was laboring to keep up normal speed, while the brushes on the commutator were spitting fire and letting out an unearthly squeal every once in a while.

The engineer spied a lamp cord on the floor, and yanking out his jackknife, he cut this off a few feet back from the lamp and skinned the ends of the two wires, making an improvised test lamp. Testing across the terminals of the machine, he found that the light came up glaringly bright. Readjusting the rheostat to about the point where he normally had it when cutting in this unit and having one of the men slow it down with the throttle, he finally reduced the voltage to a point where it was slightly more brilliant than when placed across the bus terminals.

Stationing a man at each throttle with orders to the one at the larger unit to open up quite lively if he managed to cut it in safely, he slammed in the switch.

The larger machine took more than a fair share of the load, but no serious difficulty was experienced. Two minutes later the load had climbed up to normal for the larger machine. If it had not been cut in by this time, the other machine would certainly have tripped the circuit-breaker and left the plant in darkness.

THE EQUALIZING SWITCH WAS BROKEN

In another plant two badly overloaded compound-wound generating units were carrying the load. A gang of men were installing an additional unit alongside the other two and were bringing in one of the heavy parts with the crane. It was coming along quite lively, and when passing one of the pedestals for the equalizing switch in front of one of the units, it made an unexpected swing and knocked this clear off, breaking the connections.

The two machines never got along very well together even with the equalizing switches in, and the moment the switch was broken one of the units started to take the load while the other began to take things easy.

The switchboard was some distance from the engines, and the man in charge of them saw that he had a small chance of getting to the board and adjusting the rheostats before the one machine would trip out. The engineer saved the day, however, by an ingenious trick. Grabbing the two leads to the broken switch, he laid the two bare ends on the cement floor and dropped a heavy casting on them. This renewed the equalizing connection, and the machines promptly and with good grace took up their equal shares of the load.

AN OILER SHOWS COMMENDABLE PRESENCE OF MIND

While attending to the oiling of his machines on the first deck of a 250-ton York vertical machine, the oiler in a large refrigerating plant showed rare presence of mind that would do credit to a more experienced man. While up there the stuffing-box blew out a cloud of ammonia, at suction pressure. The pressure forced the fumes directly downward, and for the moment the oiler was above them and out of danger.

Noticing that there was a window even with the top deck, leading out on an adjoining roof, he yelled to the engineer at the machine to shut it down, which he did and ducked. The oiler gave the suction valve a spin that sent it nearly shut and a few more turns were sufficient to shut it tight. He then raced to the upper deck and did likewise to the discharge valve. By this time breathing was getting difficult and the tears in his eyes blinded him, but he found his way out through the window onto the roof. The ammonia loss was not noticeable, owing to his quick action. A month later the same thing happened an another machine on the night shift and over 1500 lb. of ammonia was lost. During a hot spell one summer an ammonia suction line sprang a leak in one of the rooms where a large number of people were working. In a short time the fumes were too strong for them to remain in there with the windows shut. If the windows had been opened the temperature would have been too high for the product handled, so it looked as if the department and possibly a large number of the others would have to be shut down until the leak was repaired. The plant was running night and day on rush orders. Repairing the leak would require the better part of a day, as it was in an awkward position and two other joints would have to be removed before it could be reached.

HOW THE ENGINEER STOPPED THE LEAK WITHOUT A SHUTDOWN

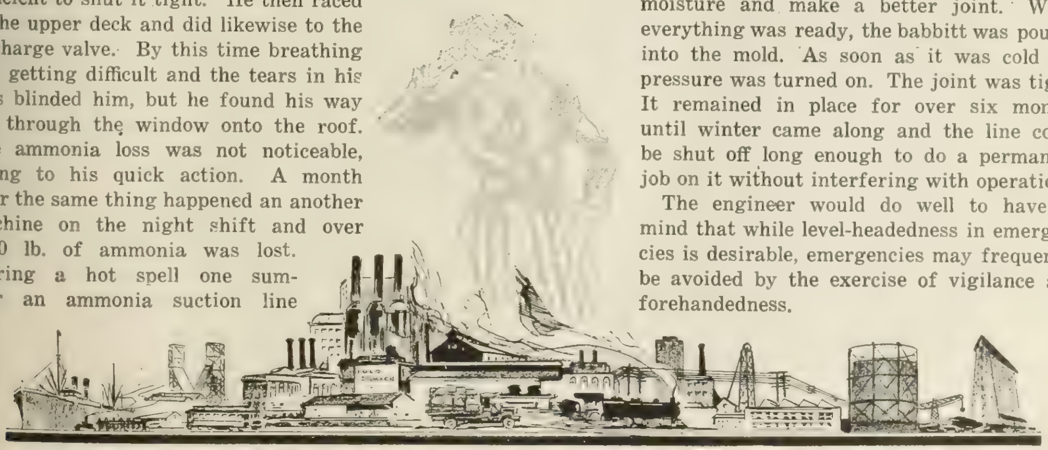
The engineer solved the problem. First he wrapped some burlap around the joint and rigged up a hose to run a small stream of water over it and down into a barrel underneath. This absorbed the ammonia fumes as the leak was not very bad, but only a little is sufficient to make the air unbearable in a closed room. A man was stationed to carry the water away from the barrel as it filled up. This allowed the men to go to work again.

He next found a pipe slightly larger in diameter than that of the flange of the joint where the leak was located. This was sawed in halves. Two boards had holes cut in them of the same diameter as the pipe and these were also cut in halves. When he was ready to go to work, two large ladles of babbitt were melted on a forge near the room where the work was to be done. The line was pumped down until the leak stopped and the machine was run slowly to hold it just at this point.

The two halves of the pipe were then placed over the leaky joint and clamped in place. The two boards were butted up to hold the split pipe and the two halves of each board nailed together with crosspieces. By means of ropes they were then pulled tightly against the ends of the pipe. A plank was placed across two stepladders for the pipe to rest on and the whole banked up with fireclay. A hole had been drilled at each end of the split pipe, one for pouring the babbitt and the other for an air vent.

Just before the split piece of pipe was placed over the joint, it was heated with blowtorches to remove the moisture and make a better joint. When everything was ready, the babbitt was poured into the mold. As soon as it was cold the pressure was turned on. The joint was tight. It remained in place for over six months until winter came along and the line could be shut off long enough to do a permanent job on it without interfering with operations.

The engineer would do well to have in mind that while level-headedness in emergencies is desirable, emergencies may frequently be avoided by the exercise of vigilance and forehandedness.



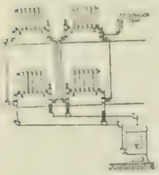
Revision of A. S. M. E. Boiler Code

Parts I and II, Section II

THIS PORTION of the A. S. M. E. revised boiler code relates to revisions in Part I, Section II, Heating and Hot-Water Supply Boilers; Part II, Existing Installations, and the Appendix. It does not apply to economizers or to feed-water heaters.

UNDER the heading, "Maximum Allowable Working Pressure" a number of important changes have been made in this section of the Code. Quite extensive additions have been made to Par. 338. These additions indicate that the pressure to be allowed on a boiler used on a closed system, either for hot-water heating or hot-water supply, shall be one-half that allowed on the same boiler if operating on an open system. This paragraph also defines what is meant by open and closed systems (see A).

The wording of Par. 339 has been changed, apparently with the object of using fewer words and more clearly expressing the intent of the original paragraph.


A

Par. 345, which relates to the subject of washout holes, has been changed so that its provisions apply equally to steam-heating boilers and boilers used for hot-water heating, as well as to hot-water supply boilers.

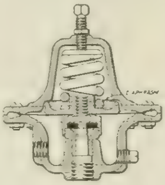
A change made in Par. 349 makes it clear that its provisions shall apply to both hot-water heating and hot-water supply boilers. This paragraph also indicates that water-relief valves that may be used on such boilers shall be of the diaphragm-operating type. It is further specified that such valves shall be so designed that the diaphragm will fail at a pressure not in excess of 50 per cent. above the allowed pressure, in case the valve fails to operate (see B). Not allowed (see C).

The later portion of old Par. 349, which related to the discharge connections from water-relief valves, has been made Par. 350 in the new Code. This rule in regard to water-relief valves for hot-water boilers built for maximum allowable pressures in excess of 30 lb. pressure, as given in Par. 350 in the old Code, has been removed.

The permissible sizes for safety valves and water-relief valves, as specified in Par. 351, have been changed. The limiting sizes for the range, 1 to 4½ in., as given in the old Code, now refer only to safety valves. Water-relief valves may be ¾ to 2 in. in size.

In Par. 352 duplex valves have been added, so as to make it clear that this type of valve is allowed (see D).

A change has been made in the requirements for the lifting gear for safety valves, as given in Par. 356. This requires that such gear shall be capable of lifting the valve $\frac{1}{16}$ in. from its seat instead of one-tenth the nominal diameter of the valve as required by the old Code. This change is the same as made for safety valves for power boilers.


B

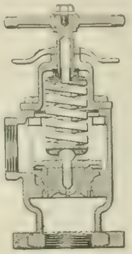
The capacity required for safety valves for heating boilers, for both steam and water heating, as given in Par. 358, have been changed. The actual amount of capacity for the safety valves for steam-heating boilers has not been changed, but a new table for determining such capacity has been placed in the Code. The values for the evaporation per square foot of grate surface, as used in this new table more nearly meet the conditions found in heating work. A new table has been added, Table 9A, to show the requirements for capacity of water-relief valves. The formula in this paragraph, 358, has been changed so that W now represents the weight of water evaporated per square foot of grate per hour instead of per second, as formerly.

An addition to Par. 360 provides for the determination of the capacity required for a relief valve when placed on a heater heated with steam.

Changes made in Par. 361, in regard to connections for steam-pressure gages, specify that if the gage is located more than 5 ft. from the boiler, the connecting pipe, if less than 1-in. pipe size, shall be of brass, copper or bronze composition. Where the distance to the gage is less than 5 ft., the connecting pipe, if less than ½-in. pipe size, must be of brass, copper or bronze composition.

Similar changes to those made in Par. 360 have been made in Par. 361, relative to pressure and altitude gages for hot-water boilers.

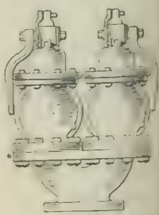
An addition to Par. 363 requires that a temperature regulator must be used in connection with all hot-water heating systems where the pressure exceeds 30 lb. and also on all closed systems, irrespective of the working pressure. Such regulators must keep the temperature of the water from rising above 200 deg. F.


C

Extensive changes have been made in Par. 374. The first change is in regard to the pressure to be allowed on a cast-iron boiler used for hot-water heating or hot-water supply; the old Code gave no limit to the pressure that might be used on such a boiler, provided it satisfactorily withstood a test of 2½ times the working pressure. The new Code limits the pressure to be allowed on cast-iron boilers to 160 lb. It is further provided that boilers intended for use on closed systems must be tested to twice the pressure required under the same conditions for boilers to be operated on open systems. Field tests, equal to the shop test, must be applied to all boilers to be operated on open systems at pressures in excess of 50 lb. or on closed systems in excess of 25 lb. These tests are 2½ and 5 times the working pressure, for open and closed systems respectively.

Changes have been made in Par. 377 to provide for proper stamping to indicate the pressures for which a boiler is designed and constructed for use in connection with either a closed or open system. It also provides that heating boilers, built under the Code rules, shall be stamped "A. S. M. E. Standard."

PART II—EXISTING INSTALLATIONS


D

Few changes have been made in the rules for boilers already installed. The most important change noted in this section is in relation to Par. 384, which deals with the condemnation of boilers in which a lap-seam crack has been discovered. The wording of the old paragraph was as follows: "No pressure shall be allowed on a boiler on which a crack is discovered along the longitudinal riveted joint." As will be noted, this wording did not define any particular class of crack. It is clear, from the revised wording, that the kind of crack that was meant was what is commonly known as a "lap-seam crack." The original wording would have required the condemnation of a boiler if any other kind of a crack appeared at the longitudinal seam. The revised wording of Par. 384 makes it clear as to the kind of crack that is referred to as well as stating definitely that the rule is to apply to butt-strap constructions as well as to lap seams (see E).

A change in Par. 402, which deals with the arrangement of blowoff connections, adds bronze and brass as materials allowed for the fittings that may be used on such connections. A new sentence has been added to this paragraph, specifying that in case of replacement of the fittings of pipes on blowoff connections, the installation shall be in accordance with the rules for new construction.

Old Par. 409 has been placed with Par. 408 and an entirely new Par. 409 placed in the Code. The subject of this new paragraph is repairs. It specifies that when repairs are to be made that will affect the safety of a boiler, a properly qualified inspector must be consulted in regard to them.

APPENDIX

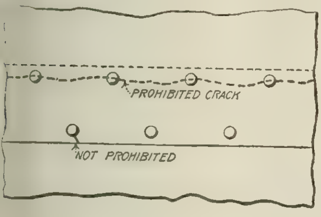
A number of changes have been made in the Appendix to the Code. Par. 416, which in the original Code consisted of two illustrations and the detailed instructions for calculating the efficiency of a quintuple-riveted joint, has been removed. This was no doubt a good move to save space, the quintuple-riveted joint not being adapted to boiler work.

The numbers of all paragraphs from 417 to 427 inclusive, in the old Code, have been reduced by one, a new paragraph, No. 427, being placed in the new Code and it will be referred to later.

The caption for Table XIV, which gives the net area on the segment of a head to be stayed, has been changed to indicate that the values given in this table apply only where *d*, as given in Pars. 214 and 217, is equal to 3 inches.

A new figure, 32, has been added to the appendix, illustrating various applications of Par. 205 and 206 to the staying of boilers.

The method of computing the discharge capacity for safety valves as given in Par. 420 (Par. 421 in the old Code) has been materially changed in wording. The results obtained by the use of the rules given in this paragraph are the same as in the old Code. However, the present form in which the information is given is more easily understood. There has been added a calculation for determining the discharge from a safety valve with a seat beveled at any angle. There has also been added formulas giving the weight of steam that may be handled by a valve in an hour's time.



E

The examples given in Pars. 422, 423, 424 and 425 (new numbers) have been changed so as to conform with the changes made in Par. 420.

The table giving the discharge capacities for safety valves, which in the old Code was known as Table 8 and was placed in the body of the Code in connection with Par. 274, has now been placed in the Appendix and numbered 15.

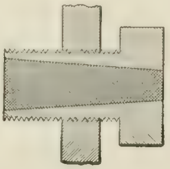
The illustrations that accompany Tables 16 and 17 (new numbers) and which were formerly known as Fig. 30, are now Fig. 31.

The new Par. 427, which has already been referred to, deals with the requirements that must be met in the construction of any automatic water gage that may be used under the Code rules. It is doubtful if any of the attachments of this kind that are now on the market will meet the requirements.

An addition has been made to Par. 428 dealing with the question of filling to be used with fusible plugs. This addition requires that the filling must be renewed once each year. This is an excellent requirement for fusible plugs if they are to be expected to operate properly (see F).

In giving the proper location for fusible plugs, in Par. 430, a new Section u has been inserted and the former Section u has become v. This new section deals with the proper water level in fire-engine boilers.

More than two pages of new material have been inserted in the Code at the end of the Appendix. This consists of recommendations in regard to repairs that may be made to boilers by the autogenous process of welding. These recommendations are the same as the rules of the Board of Supervising Inspectors given in the Steamboat-Inspection service rules for the use of this form of welding. The recommendations do not appear to conflict with the new portion of Par. 186, which deals with the subject of autogenous welding.



F

A manufacturers' data report form has been made a part of the Appendix. This form is intended to be used for boilers built under the Code rules.

The changes made in this edition of the Code appear to have considerably improved this set of boiler rules. The clearing up of a number of points that were in doubt as to the application of the rules as expressed in the old Code will be welcomed both by the manufacturers of boilers and by the inspectors who must see if the rules are lived up to.

Automatic Substation Development

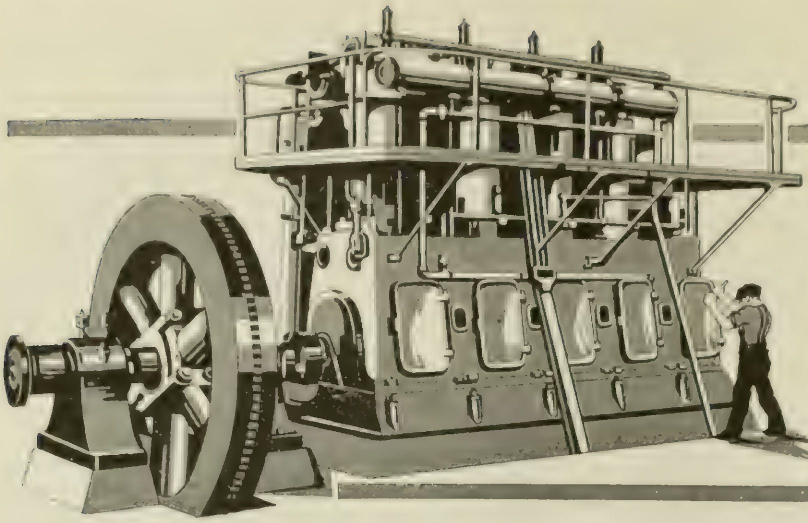
In 1912 the first substation to be controlled without an operator in the station was put into service on the Detroit Edison Co.'s system and consisted of a 500-kw. rotary converter connected to the City of Detroit's lighting system. This machine was controlled entirely by the operator in another station about a mile away. Although this station was not automatically but remotely controlled, it was nevertheless the forerunner of the automatic power plant and substation of today, the latter of which is coming into use with great rapidity.

In 1917 there was put into service in the State of Iowa a 1500-kw. automatically controlled hydro-electric power plant consisting of three 500-kw. two-phase 60-cycle 2300-volt alternators controlled through float switches by the water level in the forebay, as described in *Power*, Dec. 11, 1917. How fast automatically controlled substations are coming into use is indicated by the fact that one electric manufacturing company in this country has built and put into operation 26 such station equipments and has 30 others under construction. These stations are both rotary-converter and synchronous-motor, direct-current generator sets. Some of the motor-generator sets are to supply 1500-volt direct-current.

From the foregoing the possibilities of an automatically controlled system of power plants and substations with the machines cutting in and out automatically to meet the power demands do not look to be so much of a wild dream after all.

American-Built Locomotives Shipped to France

Shipment of more than 400 American-built locomotives weighing each 73 tons and assembled all but the smokestack and tender, so they could move away under their own steam within six hours after arriving in France, is amoung the accomplishments of the United States army transport service. This number was in addition to 1200 which were shipped in sections—nine to a locomotive—packed in cases. Ships used to transport these locomotives complete, were of special type, with three holds. Into each of the three holds was placed 12 locomotives—36 to a ship. The time consumed in the movement of the locomotive from the builders to the base of action behind the battle line was less than 12 days.



Talks on DIESEL Engines

by L.H. Morrison

VII—The men show considerable interest in the construction of pistons and J. R. explains the causes of piston troubles and methods of overcoming them.

"WHEN the meeting broke up last Thursday evening," Woods remarked to the chief, "you were talking about water-cooled pistons. What's your opinion of them, anyway? I visited the Syracuse plant a couple of months ago and they had just cracked two water-cooled pistons."

J. R. knocked the ashes from the end of his cigar.

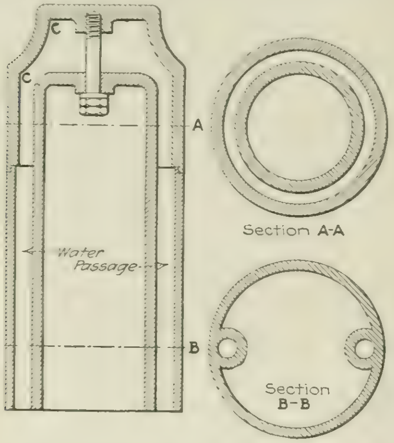


FIG. 1. PISTON LIABLE TO FORMATION OF STEAM POCKETS

"Whenever the cylinder diameter gets so big that the piston head takes up more heat than it can give up to the cylinder walls, water cooling is necessary. We have engines here with 18-in. water-cooled pistons, but I doubt whether water cooling is necessary until the pistons are larger than 20 in. Of course, a good bit depends on the speed. You can easily see that a high-speed engine might require water cooling where a slow-speed engine of the same bore would not need it. On the other hand, water cooling is more successful on slow-speed engines. At speeds of more than 200 r.p.m., the check valves in the water passages do not close quickly enough, and there is always danger that the engine isn't getting the water at all. In an inclosed engine you've got to keep close watch on the water piping.

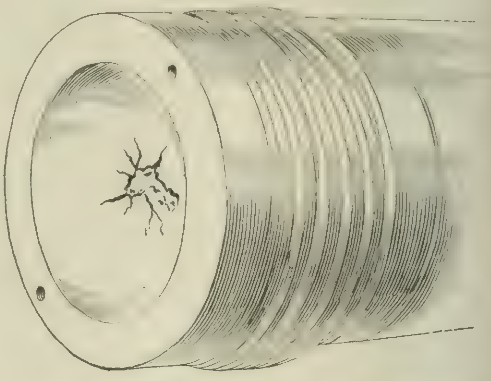


FIG. 2. PISTON CRACKED BY CARBON DEPOSITS

I know that in plants where we have water-cooled pistons, we've had a lot of trouble with leaky water connections. The water will creep into the big-end bearings and cause them to heat up.

"As for fractured water-cooled pistons," continued the chief, "I recall that the outfit you refer to is a horizontal two-cycle engine with the exhaust ports uncovered by the piston, as in Fig. 1. In this engine the circulation of the water depends on the pumping action of the piston. The exhaust gases, as they pass along the bottom of the piston head into the exhaust port, give up a great amount of heat to this part of the piston head. The heat distribution over the piston head is evidently very uneven. If

At the next meeting the various causes of cracked piston heads will be discussed, and Egan will tell a story with a dramatic ending

the water circulation is not very rapid, there is a tendency for steam pockets to form at the point I mark *C*. So, if the check valves leak, the steam pressure often blows the water back through the inlet telescopic piping until the pressure is relieved. The water then resumes its proper flow, and we have comparatively cold water striking a very hot surface. Is there any wonder that you often hear of this type of piston fracturing? The two-cycle feature in the Diesel engine demands piston water-cooling, and if the piping and valves are not kept absolutely tight, the water causes fractures."

His cigar had gone out during this long speech, and he paused to relight it before he resumed his discussion of piston fractures.

"There is one all-important precaution to be taken where engines with water-cooled pistons are used," he said."

"What is that?" asked Woods.

"Well, boys, I've mentioned that leaky water piping is a common occurrence; also that this water got into the lubricating oil. Now, if the water is not removed, the entire oiling system will soon be charged with a water and oil mixture that makes a poor lubricant, especially for a Diesel engine. Therefore I say that in such installations, this oil should be passed through a steam-coil heater to boil out the water. Some depend on a filter to refine the oil. The ordinary filter will remove grit and metallic particles, but the temperature is never high enough to get rid of water."

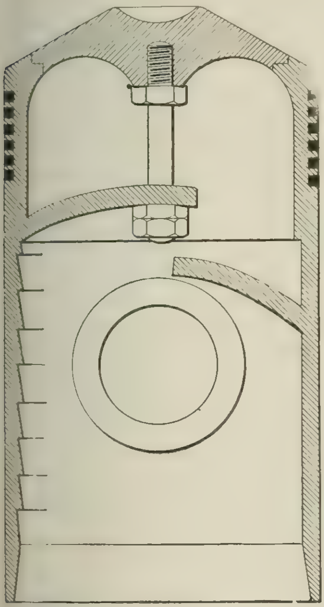


FIG. 3. PISTON BAFFLED FOR COOLING

"Well, chief," asked the ever-curious Woods, "what causes piston heads to crack even when they have strong ribs?"

"Often the core used in molding the piston is green and when the iron is run the surfaces of the ribs are chilled and very small cracks are started. These may develop into serious fractures when the engine is put into service. However, I suspect you mean those cracks which show on the face of the piston. These are usually due to carbon deposits. As you probably know, when the oil is thrown from the piston pin onto the hot piston head, a hard carbon deposit forms, and it is a poor conductor of heat. The piston head is unable to rid itself of the heat absorbed and starts to expand. Since it is strongly ribbed, it can't increase the radius of curvature of the concave portion. As a relief it sort of swells up in a ridge. When the engine stops, the metal contracts again and of course fractures develop in the readjustment of the metal."

He opened his loose-leaf book and took out a page showing Fig. 2.

"I happen to have a clipping showing a cracked piston," he said. "From the photo I would guess that carbon deposit was the cause of the trouble. In such cases the best remedy is to drill holes about $\frac{3}{16}$ to $\frac{1}{4}$ in. in diameter all along the fracture, spaced about $\frac{1}{8}$ in. apart. After tapping these holes, screw in copper plugs and cut them off even with the surface. Then drill and tap a second set of holes between the copper plugs, and, after you insert this second row of $\frac{3}{16}$ in. plugs, peen the entire row. This lacing can be done very neatly and will prevent any blowing through the fracture and at the same time will keep the crack from extending. One advantage of the water-cooled piston is that the water cavity prevents the oil deposits from settling on the hot head."

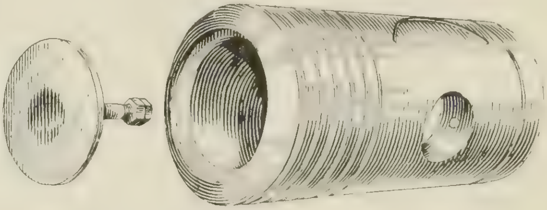


FIG. 4. BUILT-UP PISTON, SECTION OF WHICH IS SHOWN IN FIG. 3

"If that is true," Woods ventured, "why don't the builders make a false head or a partition to keep the oil away?"

"The objection, Woods, is the difficulty of cleaning the head in case the oil should get by the partition. Another thing you should bear in mind is that the air currents set up by the moving piston help to a considerable degree in cooling the piston. A partition would destroy this effect.

"However," continued Egan, "a builder of horizontal engines has used the baffle idea in his engine, as shown in Fig. 3. The baffling in this case is in two parts, to allow the air to partly cool the head. Here's another view of this piston"—he showed them an illustration similar to that in Fig. 4.

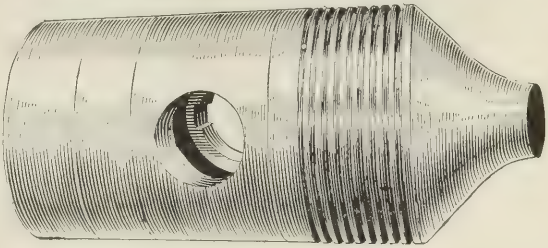


FIG. 5. PISTON FOR HORIZONTAL ENGINE

"What's the idea of the manhole plate in the piston head?" inquired Kelly.

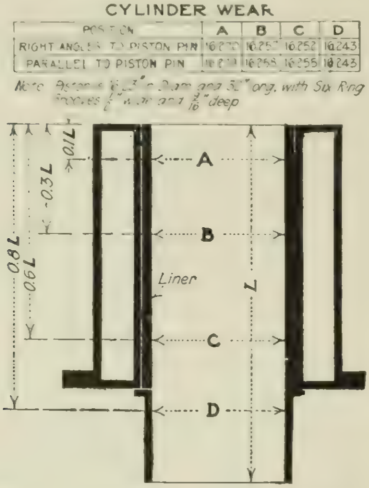
J. R. indulged in a hearty laugh before he attempted to reply to the question.

"That isn't a boiler, Kelly. It's a piston. The thing you call a manhole plate is a removable piston head. This feature is new but successful. It has been found that the pistons of horizontal engines are subject to distortion, which is not usual in the vertical type. This is due probably to the weight of the heavy piston being at all times on the bottom, which might tend to flatten the piston.

"Now, if the piston is made as snug as in the vertical engine, the expansion of the head causes further distortion and usually the piston will stick. We could obviate this by making the clearance between walls greater, but in so doing we would lose the compression. If the head could be made of a material that did not expand under heat, the distortion would not occur. Consequently, the head is made of a nickel-steel alloy which has a low coefficient of expansion. I do know that piston sticking was very common in one make of horizontal engine until alloy-steel heads were used."

"If a little bit is good, a whole lot ought to be better," said Kelly. "So why not make the whole piston of nickel?"

"Too expensive," Egan answered. "Besides, it's too hard for a rubbing surface. The best material for pistons is good gray cast iron. It machines easily, polishes well and maintains a glass-like surface. Pistons should always be made of a softer iron than the cylinder liner. If you ever have a piston made at a machine shop, insist that it be cast from iron having a small amount of scrap in it.


CYLINDER WEAR

POSITION	A	B	C	D
RIGHT ANGLES TO PISTON PIN	16.270	16.257	16.252	16.243
PARALLEL TO PISTON PIN	[illegible]	16.258	16.255	16.243

Note: Piston is 16 3/4" Diam and 52" long, with Six Ring Grooves 1/2" wide and 3/16" deep

FIG. 6. MEASUREMENTS FOR FINDING WEAR OF CYLINDER

"Another example of horizontal engine piston is shown in Fig. 5. Here the manufacturer allows for the expansion by making the head in the shape of the frustum of a cone."

Egan unfolded a blueprint and smoothed it out on the table, disclosing a drawing like that in Fig. 6.

"The Diesel superintendent left this last week," he said, "with orders that we were to take the indicated measurements every time we pulled a piston. You see, two measurements of the cylinder diameter are taken—one parallel with the piston pin and one at right angles to it—at each of the four points indicated. The figures in the table at the top are the actual measurements taken from one of the company's engines. This looks like a good scheme to follow, for it shows the wear that takes place."

Woods was ready with a question.

"How often should pistons be pulled?" he asked.

"If there's no pounding or loss of compression, about once every four months will do. That's our rule here, and I've noticed that if we wait much longer the piston rings are badly gummed up. When a piston is pulled, it should be cleaned thoroughly with kerosene, all soot scraped from the top, all carbonized oil removed from the interior and all rings cleaned. In many ways the piston is the life of the engine.

"Now, on engine liners little need be said. Some still cast the liner solid with the jacket walls, but gradually they are all coming to the removable liner. It gives little trouble and outside of reboring seldom needs attention."

"What about reboring?" Woods spoke up. "Can a liner be rebored?"

"Sure! It's often done. I believe any liner has ample thickness to stand one reboring. But in reboring the average engineer is up against a snag. Even where the plant contains several engines, it isn't profitable to own a boring bar, for that represents an investment of about six hundred dollars. Such a plant will not do enough reboring to cover the interest and depreciation. Our own company, with its several plants, has one, and of course it's used fairly often, especially on the old engines. A fair charge for reboring a cylinder from 16 to 18 in. in diameter is $150. So always recommend that this be performed by some shop that has a boring bar.

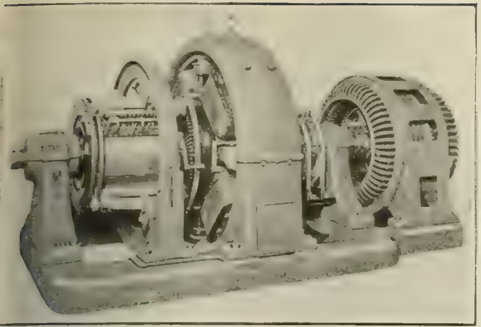
"There's one more thing, before we quit for tonight. You want to take care in pulling vertical pistons. As you know, there are usually two eye-bolt holes in the piston. I've noticed some of you are in the habit of merely passing a chain through the eyebolts and looping it over the hoist hook. Don't do that—you're liable to break off the bolts. Put a spreader between the parts of the chain, near the piston, so that the pull on each bolt is in line with its axis. Of course, if the piston is tapped for only one bolt, this doesn't apply."

Boiler Feed-Water Treatment and Metal Preservatives

By P. R. Duffey

Many companies will purchase, upon a salesman's recommendations, a trial lot of water or metal treatment and with a few hasty instructions turn it over to the chief or operating engineer for trial. The engineer in turn, has probably learned to be doubtful of good results to be obtained, will make a hurried test perhaps in a haphazard way and condemn the possibly good and needed treatment.

In order that he may find out the truth the chief engineer, or the man held directly responsible for the boiler plant, should personally inform himself of all details possible for the manufacturer to give, and follow up the tests over a sufficient period of time to warrant his approval or rejection of the treatment. The manufacturer should conscientiously represent his goods and give the purchaser the benefit of his experience, impart all information possible and follow the method used by the man detailed to perform the test, being satisfied that a square deal is given each party. The water and metal treatments now on the market will no doubt do what is claimed for them if properly used, but if not used as intended, it is likely they will fail.



Electrical-Machinery Brush Composition

By WARREN C. KALB

The Various Types of Brushes Used on Electrical Machinery, Their Composition, Method of Manufacture and Field of Application

CONSIDERING brushes in relation to the materials of which they are composed, they fall into eight classes as follows: Carbon-graphite, graphite-carbon, graphite, electrographitic, metal-graphite, carbon-gauze, metal-gauze and copper leaf.

The carbon-graphite brush is the type usually spoken of as an ordinary carbon brush. It is composed principally of amorphous carbon, usually in the form of coke, to which is added sufficient graphite to give the brush some lubricating property and increase its conductivity to some extent. Natural graphite is generally used for this purpose, and as this usually contains a considerable percentage of foreign material of more or less abrasive nature, brushes of this class as a rule are abrasive to an appreciable degree.

The practice is quite common among both manufacurers and users to impregnate brushes of this class with some lubricating material. This not only tempers he abrasive characteristic of the brush and reduces ts friction, but improves the commutating property as well, due to the higher contact resistance created by the film of lubricating material which forms at the brush face.

The disadvantages of this treatment are that it is driven off when the brush encounters conditions of high temperature. It has a tendency to collect dust from the atmosphere, and if this happens to be of an abrasive nature, as is the case around cement mills and similar service, the commutator wear resulting from his cause may be quite severe. Finally, brushes with ubricating treatment have a much greater tendency han others to collect copper on the face of the brushes.

Most brushes of the carbon-graphite class are within he medium range of hardness. They are not adapted to undercut mica, due to their abrasiveness and the artificial lubrication they generally require. Most grades of this class are of low carrying capacity and are not adapted to high peripheral speed. However, his type of brush will take care of a wide range of operating conditions within the limits of its characteristics and, considering its moderate price, must be classed as a good all-around brush.

There is another class of brushes in which a coniderable or even the predominating percentage of the omposition is graphite, the remainder being coke or ome other form of amorphous carbon. These are known as graphite-carbon brushes. A great many grades of brushes fall within this class, so that the lass as a whole covers a very large field of application, lthough the individual grades may not apply to such a broad range of service.

Brushes in this class usually contain sufficient graphite for lubrication, so that lubricating treatment is seldom used. Artificial as well as natural graphites are used, depending on the characteristics that it is desired to incorporate in the brush, and the abrasive properties will depend upon the graphite that is selected. Some brushes within this class possess very little abrasive action, while there are others possessing considerable. In point of hardness these brushes will range from soft to medium hard. The carrying capacity will usually be higher than the grades in the carbon-graphite class, but the contact drop of most of these brushes is medium or low unless a lubricating treatment is used.

Brushes of this type find an extensive application on industrial motors, moderate-speed generators, mining- and mill-service, and railway motors. Certain grades of this type are especially well adapted to fan motors, magnetos and other small machines both of the direct-current and universal types. Some excellent grades of moderate-priced brushes will be found among the various makes of graphite-carbon brushes.

There are numerous grades of brushes on the market composed entirely of graphite except for the binding material necessary to hold the particles of graphite together. These are characterized by high-carrying capacity, medium contact drop and low coefficient of friction, adapting them especially to high commutator speeds.

There are a few grades of graphite brushes on the market manufactured by special methods that give the material a very high resistance and a somewhat improved commutating characteristic over the ordinary type of graphite brush. These grades, however, have a rather limited field of application. There are also grades possessing very low specific gravity. These are manufactured in this way to reduce the inertia of the brush as much as possible, adapting it to very high rotative speeds.

Most brushes in the graphite class are nonabrasive or at most but slightly abrasive and should generally be used on commutators of which the mica is undercut. A few of the slightly abrasive grades can be used on unslotted commutators where conditions are not severe. All the brushes in this class are soft, some of them being very soft. They possess low mechanical strength, so are incapable of meeting severe mechanical conditions and should be operated at low spring pressure. Where quietness of operation is an essential characteristic, this type of brush has much in its favor. Classes of service in which they are used to a considerable extent are as follows: Turbo-generators and other high-speed types, automobile-lighting generators, electric-vehicle and battery-locomotive motors, battery-charging and other low voltage generators, slip rings and occasionally as lubricating brushes on electroplating generators.

ELECTROGRAPHITIC BRUSHES

Perhaps the highest stage in the development of carbon-brush manufacture up to the present time has been reached in the electrographitic brush. This type is made up in the first place of certain forms of amorphous carbon carefully selected to give the desired characteristics to the finished product. In the final baking operation it is carried to an extremely high temperature, which results in a modification of the material composing the brush, leaving all or part of it in the form of graphite. It is possible to make this type as near absolutely nonabrasive as any brush can be made. It is also manufactured with varying degrees of abrasiveness to meet special requirements.

In relation to other types of brushes this class is hard and some grades are extremely so; still, owing to its dense structure high conductivity is attained. Mechanical strength and toughness are pronounced characteristics of nearly all grades. The commutating properties of brushes of this class are above the average, and by proper selection of raw materials it is possible to secure a very high contact drop without the use of any impregnating treatment. This high contact drop, combined with the high conductivity and low coefficient of friction, gives an ideal combination of brush characteristics, making certain grades applicable to a very wide field of service.

Electrographitic brushes have been used on practically every conceivable application except electroplating generators, and even on these the more graphitic grades are sometimes used for lubrication. The nonabrasive grades are especially well adapted for use on undercut commutators, the hardness of the brush giving a cleaning action, which polishes the surface of the commutator well without causing any wear. For use on collector rings the electrographitic brush is well adapted wherever mechanical conditions are severe, due to its greater ruggedness.

These brushes may be used up to current densities as high as 80 amperes per square inch on the alternating-current rings of rotary converters, and occasional instances of successful application at even higher current densities have been noted.

TREND IN THE USE OF BRUSHES

The trend of development at the present time seems to be away from the use of metal-graphite brushes on slip rings and toward the use of graphite and electrographitic brushes at current densities that are suited to these grades. There are many things to be said in favor of this tendency on all classes of alternating-current machines. However, a serious objection is met with on induction motors of the slip-ring type where it is desired to keep the slip at as low a figure as possible. Here the higher contact drop of graphite and electrographitic brushes will result in a greater percentage of slip than will be experienced with metal-graphite brushes.

For certain classes of service a brush is required having a contact drop much lower than that possessed by any carbon brush, yet above that of pure metal. For this purpose brushes are manufactured of a composition made up of graphite and metal powder. Copper powder is used in some grades. However, pure copper powder does not make the best brush for use on slip rings, owing to its tendency to cut the rings. For this reason it is customary to alloy the copper to some extent with tin, zinc, lead or some other metal, making a brush that is much less liable to score the rings. Copper, however, remains the predominant element in the composition.

The materials are thoroughly mixed in the desired proportions with a binding material to hold the metal and graphite particles together. It is then molded at high pressure, after which it is baked to carbonize the binder. In some grades the binding material is omitted and the temperature carried to a point of partial fusion of the metal, so that the material is bound together into a compact mass without the use of any additional binding agent. In addition to raising the contact drop somewhat above that of the pure metal, thus making it possible to secure good commutation on machines of low voltage, the graphite has another function—that of lubrication. Where properly applied these brushes can be used on commutators and slip rings at a fairly high peripheral speed without difficulty being encountered.

BRUSHES FOR USE ON SLIP RINGS

On machines of the commutating type the selection of the proper grade of brush depends largely on the commutating characteristics of the machine, a brush of sufficient contact drop being required to keep short-circuit current well within control. On collector-ring service the selection is based on the required carrying capacity of the brush and its freedom from cutting. The lower the contact drop the better suited for this service, other characteristics being correct.

Considerable difficulty has been encountered at times in the attempt to apply metal-graphite brushes to service on collector rings. This usually takes the form of rapid brush wear and serious cutting of the rings. Undoubtedly, this condition is influenced to a considerable extent by the relation between the composition of the ring and that of the metal in the brush.

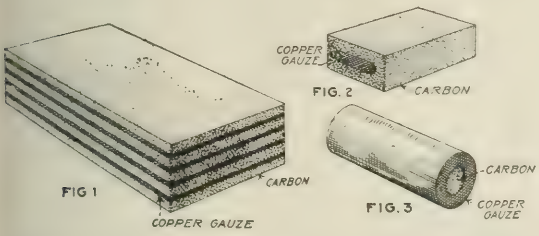
Another source of considerable cutting has been the tendency to use too high current density in metal-graphite brushes. In best practice at the present time a current density of 125 amperes is never exceeded with brushes of the highest metal content, and it is a frequent practice to keep the current density down to 100 amperes or less.

When current densities are kept this low on collector-ring service, much of the advantage of the composition brush is lost except on slip-ring type induction motors where it is desirable to keep the slip of the motor as low as possible. For this reason there is a growing tendency toward the use of graphite and electrographitic brushes on collector-ring service putting on brushes of sufficient size and in sufficient number to keep the current density around 75 to 80 amperes per square inch. This practice has an added advantage in certain classes of service, such as cement mills, where the tendency for cutting is aggravated by the presence of an abrasive dust.

It is a characteristic of the composition brush that when the polish of the brush face and the collector ring is once destroyed there is a tendency for the cutting to continue for a considerable period before the polish again forms. This is not the case with electrographitic brushes and is one of the reasons this type of brush is meeting with increasing favor for service under conditions such as those just described.

While the tendency is away from the use of composition brushes on collector-ring service, this type of brush is still holding its own on low-voltage machines of the commutating type and possesses many advantages over any other type. Some of the classes of service in which it is extensively used are automobile-starting, lighting and ignition apparatus, railway-switch and signal motors, and electroplating generators.

One of the earlier attempts at the manufacture of composition brushes took the form of a carbon-gauze brush made up with alternate layers of metal gauze and carbon, Fig. 1, the carbon layers usually being about ⅛ in. thick. This brush had an appreciably higher conductivity than the ordinary carbon brush, owing to the longitudinal layers of gauze. Its commutating property, however, approached that of carbon except for the narrow line where the gauze layer came in contact with the commutator. Owing to the tendency of the gauze to burn back from the contact face of the brush this brush was not successful on machines of high voltage. On low-voltage machines, however, it met with considerable success and is still used on some types of electroplating generators and low-voltage motors. It is especially well adapted to machines that must operate over a wide voltage range, such as certain types of switch motors which operate as a motor on 110 volts and generate a short-circuit braking current of low voltage after the power is thrown off the motor. An all-carbon brush of sufficiently high contact drop to commutate on 110 volts will not pick up the generating action quick enough to function properly on this type of motor. The presence of the gauze, however, accomplishes this result. This brush also finds considerable application on collector-ring service.



FIGS. 1 TO 3. TYPES OF CARBON-GAUZE BRUSHES

Small brushes of carbon and gauze combination are frequently manufactured by inserting a core of metal gauze in a hollow shell of carbon, Fig. 2. Still another type is made by winding a few layers of gauze around a core of carbon or graphite, Fig. 3. Such brushes have a limited field of application on magnetos and certain machines of special design.

In the last two types of brush it is customary to use brass gauze instead of copper, inasmuch as sufficient conductivity is given to the brush in that way and the brass gauze is much less liable to scratch a commutator than is copper gauze. In the layer type of brush, however, where the area of contact of the gauze is distributed, this precaution is not necessary and copper gauze is used. There is no fixed ratio for the proportion of gauze to carbon in these brushes, the types illustrated representing what is perhaps an average proportion.

Metal-gauze brushes are composed entirely of metal gauze, the process of manufacture being to wind this gauze into a roll as compactly as possible, after which it is pressed into the desired shape. In some cases the pores of the brush are then impregnated with graphite to furnish a lubricating action. This type of brush finds some use on automobile-starting motors, electroplating generators, and slip-ring service, but is being largely superseded in all of these fields by the metal-graphite composition brush.

Copper-leaf brushes are composed of a large number of layers of thin copper strapped or soldered together at different points to prevent their spreading. About the only application to which this type of brush is adapted is collector-ring service. Even on this service it is troublesome, requiring frequent attention to keep the face of the brush trimmed up and the rings lubricated to avoid cutting, therefore it is rapidly passing out of use.

(The next and last article will consider the application of brushes to electrical machinery to meet the conditions met with in various industries.)

A Legal Aspect of Boiler Rooms

By A. L. H. Street

An employee of a factory in an occupation unrelated to the power plant, on coming to the factory one morning pursued common practice in going to the boiler room and placing on a boiler a bottle of tea to keep it hot until her midday meal. On her way out of the boiler room she slipped on a staircase and was injured. Her right to collect compensation under the New York Workmen's Compensation Act was denied on the ground that she was not injured within the course of her employment, within the provisions of the act. But the Appellate Division of the New York Supreme Court overrules this contention and sustains an award in claimant's favor, saying:

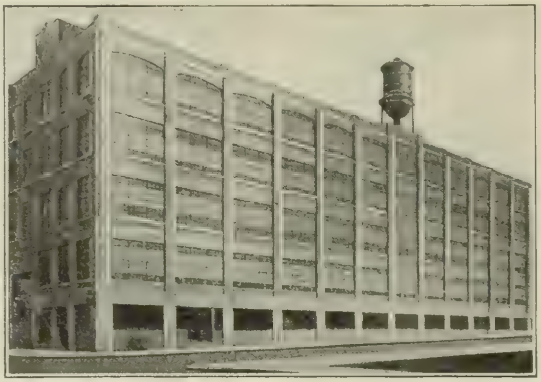
> In order to be acting in the course of her employment, it was not necessary that she should have been actually engaged in the work thereof. It was sufficient if she was performing some act upon the premises of her employer which, though directly beneficial to herself, was an ordinary incident of a day of employment.
>
> This claimant was performing such an act in placing her bottle of tea upon the boiler to keep it hot for a midday meal. Of course, if she had been forbidden to enter the boiler room, she was acting in violation of her duty and therefore not in the course of her employment. It is true that her employer had long previously promulgated a rule prohibiting the use of the boiler room and the boiler by its employees. However, it was the common practice of employees at the time of the accident to make use of the room as did the claimant. The acquiescence of the employer in this practice was sufficient to abrogate the rule. (Etherton vs. Johnstown Knitting Mills Co., 172 New York Supplement, 724.)

The Mechanical Equipment of Industrial Buildings—I

By CHARLES L. HUBBARD

The author treats broadly of the selection of equipment for industrial buildings. In this installment he considers sources of power and power and heating requirements.

THE accompanying illustration shows a type of building that has been erected in large numbers during recent months, owing to war conditions. Something relating to its mechanical equipment should therefore be of especial interest to designing and operating engineers. The subject will be treated somewhat broadly, taking up matters connected with the selection and arrangement of equipment and general methods of operation rather than details of construction. The great variety of manufactures carried on in such buildings makes it impossible to touch upon the special devices employed in actual production, but such matters as power generation and distribution, heating, ventilating, etc., are more or less common to all, and this article will therefore be confined to those subjects.



COMMON TYPE OF MODERN INDUSTRIAL BUILDING

There are three possible sources of power, depending upon local conditions: Electric power, purchased from a central station; a private water-power development, either adjacent to the building or having electrical energy transmitted from a distance; and a steam plant located on the premises. If power can be purchased at a sufficiently low rate, it has certain advantages that should be carefully considered. Among these may be mentioned the element of time, conservation of fuel, saving in space and general convenience. In many cases buildings of this kind are rushed to completion so that if the construction of a power plant may be eliminated the saving in time will often prove an important factor.

Furthermore, the possibility that the business may be of a temporary nature (for the duration of a war, for example) should be taken into account, and this may lead to the immediate purchase of power with the idea of adding private power equipment should the plant later become established on a permanent basis. Conservation of fuel, even if the cost to the owner of the plant is practically the same, should be taken into account for both patriotic and private reasons. In general, less fuel will be required per unit of power developed in a large central station than in an isolated plant, and if the central station develops its electricity by water power the saving in fuel will of course be still greater. Under present fuel conditions it may work out to the advantage of the plant owner to purchase power, even though it may cost more than to generate it on the premises, as the supply may be more reliable. For example, if power is obtained from a large hydro-electric plant, fuel shortage will have no direct effect on the continuous operation of the factory, and even when purchased from a station employing steam power there is less liability of interruption than would be the case with a private plant of much less importance. An enforced shutdown of a week or two, due to fuel shortage, would offset a considerable difference between the cost of power from a private plant and that from a central station.

Saving in space is often a deciding factor in purchasing power, especially when the building is located where land is expensive. In taking into account the space occupied by a power plant, it is necessary to include not only that required for the generating units and their auxiliaries, but also that necessary for the storage of coal, the handling of ashes and possibly side tracks, etc., connected with this equipment. As a matter of general convenience, nearly all points are in favor of purchased current. There is less likelihood of a shutdown for repairs, and many details relating to water and fuel supply are eliminated. It is true that the buildings must be heated, but this is necessary for only about half the year, whereas power requirements are continuous. Until the advent of electrical transmission of power it was necessary, in case of water-power development, to locate the factory beside the stream. As other requirements had to be considered, such as transportation, nearness to centers of population, etc., steam power was largely relied on for driving shops and factories, except in special cases.

Electrical transmission, together with the shortage of fuel, has again turned the attention of the engineer to the development of unused water powers. While the more extensive ones have already been taken up by large power companies, there are still available good opportunities on some of the smaller streams for the development of power sufficient to supply the needs of factories of fair size. When these are within reasonable distance of desirable sites for manufacturing plants, they should be considered as possible sources of power. When the time element is an important factor, or where there is a liability that the life of the factory may be limited to the special market conditions caused by a war, it may not be advisable to consider hydraulic power unless the outlook is especially favorable. In instances of this kind it may be possible to purchase power temporarily, with a view to installing a private hydro-electric plant at a later date if market conditions favor a permanent layout of this kind.

In each of the cases thus far considered, attention has been confined to the power side of the problem only. In the greater part of the country, and especially in the more important manufacturing sections, the factory must be heated for a period ranging from four to seven months of the year. This condition has an important bearing on the selection of a source of power because during the heating season, when exhaust steam can be utilized for heating and ventilating, the actual fuel requirements for power alone are comparatively small. For example, in the average case, less than 20 per cent. of the steam supplied to the engine is condensed in the performance of useful work and in the cylinder losses.

If an engine is using 24 lb. of steam per indicated horsepower-hour and 80 per cent. of this is utilized in heating the building, only 24 × 0.20 = 4.8 lb. of steam per indicated horsepower can be charged to power development. The building must be heated, and if the steam can first be passed through an engine or turbine the actual expenditure for power will be very small, as just shown. In making an estimate of this kind, however, it is necessary to consider only the exhaust that can be utilized and not that which is produced; and furthermore, the entire twelve months of the year must be taken into account. In a general way, the heat loss from a building of this type is large, and perhaps all, or at least a considerable portion, of the exhaust can be utilized, especially in the colder months. In other cases, where the manufacturing is of such a nature as to require only a minimum of power, the exhaust may not be sufficient for heating purposes, in which case the full benefit will be realized, as in the example previously given.

STEAM CHARGED TO POWER ACCOUNT

Suppose, for illustration, that the available exhaust is just sufficient for all heating purposes in zero weather and that the plant is run 2700 hours per year. Suppose also that the heating season lasts seven months, with an average outside temperature of 35 deg. F. (average conditions for New England and similar latitudes). Taking the same engine as before, the steam requirements per horsepower per year are 24 × 2700 = 64,800 lb. While the total exhaust, or 24 × 0.80 = 19.2 lb. per indicated horsepower-hour, can be utilized for heating in zero weather, only half that, or 19.2 ÷ 2 = 9.6 lb., can be utilized per hour when the average heating season is considered. Assuming a heating season of 1638 working hours (seven months with twenty-six 9-hour working days per month), it will be possible to utilize 9.6 × 1638 = 15,725 lb. of steam per indicated horsepower, bringing the total to be charged to power down to 64,800 — 15,725 = 49,075 lb. per i.hp., or 49,075 ÷ 2700 = 18.2 lb. per i.hp.-hr., when the average for the entire year is considered. From these results, the steam to be charged to the power account, under different conditions, is as follows: In zero weather, 4.8 lb. per i.hp.-hr.; average for the heating season, 18.2 lb. per i.hp.-hr.; and during the nonheating season, 24 lb. per i.hp.-hr.

With these data at hand it is possible to make a comparison of costs between purchased power and that generated on the premises, taking into account, of course, fixed charges on the cost of the private plant. This evidently applies only to the particular conditions assumed and for simplicity takes into consideration only the average day load for operating the plant. Additional power required for lighting, where the exhaust must be thrown outboard, must be charged up to the annual power account, thus increasing the steam per horsepower-hour. If, on the other hand, the normal day load failed to furnish the required amount of steam for heating, then the additional lighting load during the evening would furnish more available exhaust and thus reduce the annual fuel cost per horsepower-hour based on the normal day load, as in the example.

ADVANTAGE OF PRIVATE STEAM PLANT

The principal advantage of the private steam plant comes from the low cost of power when conditions are such that the exhaust can be utilized to advantage for heating purposes, and this should always be taken into account when comparing this source of power with hydraulic power or central-station service.

Among the governing factors in the selection of a boiler are the pressure to be carried, size and number of units, available space and cost. To these may be added such details of construction as relate especially to accessibility for inspection, cleaning and repairs.

When boilers are furnished by builders of established reputation, it is not usually necessary for the engineer to prepare detailed specifications. General requirements as to pressure, amount of heating and grate surface, type of furnace and setting are furnished the builder and from these he in turn prepares specifications for the owner or his engineer, which are submitted with his bid. This applies especially to water-tube and patented boilers, of which there is a great variety. In the case of horizontal fire-tube boilers the engineer often furnishes specifications, particularly when any departure from standard construction is desired.

CHOOSING TYPE OF STEAM BOILER

In making a choice between fire-tube and water-tube boilers, one must be guided largely by local conditions. So far as efficiency is concerned, for a given size, there is very little difference provided they are designed and operated with equal care. In general, return-tubular boilers are more frequently confined to plants of small and medium size and to pressures not exceeding 150 lb. per sq.in. Individual boilers are commonly limited to about 150 rated horsepower, which corresponds to a 72-in. shell with ninety-eight 3½-in. tubes 19 ft. in length. While larger sizes might easily be constructed, it has been found by experience that the shell plates should not exceed ½ in. in thickness, or ⅝ in. at the most, which limits the diameter possible with a given pressure. Boilers of this type are lower in first cost than water-tube boilers, they require a minimum of repairs, and when properly designed and set, all parts are comparatively easy of access for inspection and cleaning.

For larger units and higher pressures the water-tube boiler has largely superseded the horizontal fire-tube type. It is more expensive to install for a given capacity, but requires considerably less floor space. It is made in units of all sizes ranging from about 50 hp. up to 2000 hp. or more, so that almost any division for a given capacity may be obtained. Water-tube boilers respond quickly to changes in load and are practically immune from dangerous explosions.

In laying out the boiler plant for a manufacturing establishment, the first step is to determine the maximum steam requirements for all purposes, in pounds per hour from and at 212 deg. F., which, divided by 34.5, will give the nominal horsepower rating. The greatest steam consumption will depend on the relation between the power and heating requirements. In determining this, compute the maximum steam requirements for power and heating separately, also the average day load when lights are not required. If the available exhaust steam from the day load exceeds the maximum heating requirements, then the boiler capacity may be based on the power load alone. If, however, the maximum heating requirements exceed the available exhaust from the average day load, then the boiler capacity must be based on the power requirements at day load plus the steam necessary for heating in addition to the exhaust at day load. Furthermore, this should be checked up with the available exhaust from the maximum evening load, and if the latter is not found sufficient for all heating purposes, the total boiler capacity must be based on the evening power load plus the additional steam for heating instead of on the day load. The "power load" should include all engines, turbines, pumps, etc., of whatever kind, which are supplied with live steam, while the term "heating requirements" should include warming the buildings, ventilation, hot-water service, feed-water heating, etc.

ECONOMICAL OVERLOADS FOR BOILERS

Having determined the maximum boiler capacity in pounds of steam per hour, or its equivalent rating on a basis of 34.5 lb. per horsepower-hour, the next step is to decide on the amount of heating surface, or, to put it a different way, the percentage of overload that can be economically carried above the normal rating. Fire-tube boilers are commonly rated at one nominal horsepower for each 12 sq.ft. of heating surface and water-tube boilers on a basis of 10 sq.ft. of heating surface. With improvements in furnace construction and methods of operation, so as to burn larger quantities of fuel per unit of heating surface under conditions more nearly approaching complete combustion, it has been found that the capacity of a given boiler may be greatly increased with only a slight drop in efficiency, while in some cases the efficiency is actually increased up to a certain point.

While many tests have been run which show that a boiler may be made to develop a capacity of from 250 to 300 per cent. of its normal rating at a relatively high efficiency, the most desirable overload in any given case will depend on various circumstances, such as length of run, whether continuous or intermittent; method of firing, whether by hand or with stokers; design of furnace and method of supplying air, etc. While the best rate of forcing can be determined only by test, the following may be taken as a guide in laying out new work equipped with boilers and furnaces of the best design of medium size: For continuous operation, 24 hours per day, 125 to 150 per cent. above rating; for 10- to 12-hour runs, 150 to 175 per cent.; and for peak loads of 2 or 3 hours' duration, 175 to 200 per cent. These figures apply especially to plants equipped with mechanical stokers, where the rate of fuel supply is easily increased. In case of hand-fired plants the increase cannot usually be carried above 150 per cent. under average conditions.

The importance of increasing the capacity of a boiler in this way is readily seen, especially in shops and factories where a lighting load must be added to the ordinary day load for a varying length of time depending on the season of the year. If this can be done without adding to the number or power of the boilers required for the day load, simply by forcing them from 150 to 200 per cent., it will save materially on the first cost of the installation as well as on the expense of carrying banked fires for 20 hours or more when the boilers are to be used only 3 or 4 hours per day at the most.

VALUE OF MECHANICAL STOKERS

While the capacity of a boiler must necessarily be determined by the weight of steam to be furnished in a given time, its normal rating on the usual basis of 10 or 12 sq.ft. of heating surface per horsepower will depend on the percentage of overload it is deemed advisable to carry at times of maximum demand in any given case. It has already been stated that increase in boiler capacity depends principally on the ability to supply and burn more fuel. The first requirement is limited in the case of hand-firing; hence the importance of mechanical stokers in this connection.

The value of mechanical stokers will depend largely on the size of the plant, the percentage of overload it is desired to carry, and the possibility of installing overhead chutes and coal-handling machinery. They are generally employed in plants of 1500 hp. and over, and have also been found effective in many cases where the boiler capacity did not exceed 200 or 300 hp. As the plant diminishes in size, their advantage is offset by the added cost, not only of the stoker itself, but of the other equipment that goes with it, such as coal- and ash-handling machinery.

FACTORS GOVERNING USE OF STOKERS

Among the factors that govern the use of mechanical stokers are the grade of fuel to be used, cost of skilled labor, and smoke regulations. Under ordinary conditions one efficient fireman can attend to about 200 hp. of hand-fired boilers, while with mechanical stokers with overhead coal bins and chutes, he can easily care for a plant of 1000 to 2000 hp., depending on the grade of fuel and type of equipment. The chief advantages of this method over hand firing are saving in labor, a uniform supply of coal without opening the feed doors, and greater accuracy in proportioning the air supply to the needs of combustion, all of which are in the line of greater efficiency.

When fuel economy is an essential feature, as at the present time, a considerable saving may be made by the use of superheated steam. It has not been used in this country to any great extent in the past in connection with reciprocating engines, owing to the difficulty experienced in lubricating the cylinders and to the unequal expansion produced at such high temperatures. Improvements in design and in lubricating oils have overcome these obstacles to such an extent that superheat is now quite generally employed in the best class of work, especially in the case of turbines.

In American practice the degree commonly employed runs from about 100 deg. to a maximum of 160 deg., being limited to a total temperature of about 500 deg. F. for engines of ordinary construction. Beyond this point the expense of maintaining the superheat and increased cost of construction and maintenance soon offset the gain in economy. The saving in steam consumption depends principally on the reduction in cylinder condensation and varies with the operating conditions.

Tests of a simple noncondensing engine of medium size show a saving of 20 per cent. with 150 deg. of superheat, and 25 per cent. with 225 deg., which correspond with a saving of 1 per cent. for each 7.5 deg. rise at the lower temperature and for each 9 deg. at the higher. A compound condensing engine of the same power shows savings of 15 and 20 per cent. for the same relative conditions, corresponding to a gain in economy of 1 per cent. for each 10-deg. rise at the lower temperature and for each 11.2 deg. at the higher. Comparison of these results shows a falling off in effectiveness as the temperature increases, and a greater gain in the case of the simple engine than the compound, both of which are borne out in practice. These figures simply show the reduction in steam consumption without regard to the cost of superheating. The net gain in economy is usually not far from half of the apparent gain when the water rate only is considered.

Superheaters of the indirectly fired type, contained in the regular boiler setting, are usually employed in this class of work, owing to their lower first cost and greater compactness.

The Electrical Study Course—Two-Wire Versus Three-Wire System

Shows in what respects the three-wire system overcomes the disadvantages attendant upon operating lamps in series on a two-wire system, and gives the manner of determining the relative amounts of copper required in the mains of three-wire systems as compared with those required in two-wire systems. Also proves that in a three-wire system the percentage of energy lost in the line and the percentage voltage drop therein vary with the amount of unbalancing.

IT WAS stated in a previous lesson that the three-wire system overcomes the disadvantages encountered in operating 110-volt lamps in series on a 220-volt service and yet retains in a large measure the advantage that a 220-volt two-wire system was shown to possess over a 110-volt two-wire system; namely, that of using one quarter of the copper in the mains to convey the same amount of power with the same loss.

The chief disadvantage of the series plan is that both lights of a set must always be used together. They are either both burning or both out. The three-wire system overcomes this undesirable feature, since turning off one or any number of lamps between one outside and the neutral wire has no effect whatever on the rest of the lamps; all that it does is to cause current to flow through the neutral wire. The accidental burning-out of a lamp on one side will likewise not disturb the others.

If a short-circuit should occur in a lamp, there will be no excess voltage across any other lamp as is the case with the series connection, and consequently only the one lamp will be affected and there will be no disturbance except the possible blowing of a fuse. Thus it is seen that the principal drawbacks of the straight series arrangement are obviated by the three-wire system.

In proceeding to the matter of the saving of copper in the three-wire system, it will be remembered that in two-wire systems the weight of copper required varies inversely as the square of the voltage employed when equal loads are to be transmitted like distances with the same loss in the line. That is, if the voltage is doubled the weight of wire required would be quartered. To bring out the relations clearly and to show what the conditions in the three-wire system are, reference will be made to Figs. 1, 2 and 3, which represent a two-wire 120-volt, a two-wire 240-volt, and a three-wire 120- to 240-volt system respectively; all are supposed to be of the same length.

Assume that the load in every case is twelve 200-watt 120-volt lamps arranged as shown, and that the line loss is the same in all three cases. The total load on each system would be $12 \times 200 = 2400$ watts. The current in the 120-volt system would therefore be $\frac{2400}{120} = 20$ amperes, and that in the 240-volt system $\frac{2400}{240} = 10$ amperes. Since the loss in a line is equal to I^2R, and this loss is to be the same in all the systems, we have $(10)^2 \times R_2 = (20)^2 \times R_1$, where R_2 and R_1 are the resistances of the 240-volt and 120-volt lines respectively. From this we see that $100R_2 = 400\ R_1$, or $R_2 = 4R_1$. That is, the resistance of the 240-volt line is four times that of the 120-volt one, and in order for this to be so the wire in the former must be one-quarter the cross-section of the latter and consequently one-quarter of its weight for the same length.

Coming now to the three-wire system of Fig. 3, the current in each of the outside wires is that taken by six of the lamps—that is, 10 amperes—and the current in the neutral is their difference, namely, zero. We therefore find that this case is identical with the straight two-wire 240-volt system, since the neutral wire could be eliminated and it would operate exactly as does the two-wire arrangement. Consequently, the size, and therefore the weight, of the outside wires would be the same as those of the wires of the two-wire system. To this, however, must be added the weight of the neutral in order to get the weight of copper for the entire system.

It was found in the preceding lesson that the maximum current in the neutral would flow when all the lamps on one side were lighted and all those on the other extinguished. Hence the maximum current in the neutral will be the same as the maximum in either outside wire, in this case 10 amperes. Since it must be prepared to carry the same current as the outside wires, it must also be of the same size. This means that the weight of the additional wire must be the same as the other two.

From the foregoing deductions we have the following relations: The weight of the copper in the 240-volt system is $\frac{1}{4}$ that of the 120-volt one, and the weight in the three-wire system is $1\frac{1}{2}$ times that of the 240-volt one. To make the comparison as simple as possible, assume that the weight of the copper in the 120-volt system is represented by W. Then that in the 240-volt system will be $\frac{1}{4}W$, and that in the three-wire system $1\frac{1}{2}(\frac{1}{4}W) = \frac{3}{8}W$. That is, the copper in the three-wire system weighs $\frac{3}{8}$ as much as that in an equivalent two-wire 120-volt system, compared with $\frac{1}{4}$ as much for a two-wire 240-volt system. It is therefore evident that the three-wire system affords a very material saving in copper, even if it does require somewhat more than does the two-wire 240-volt system.

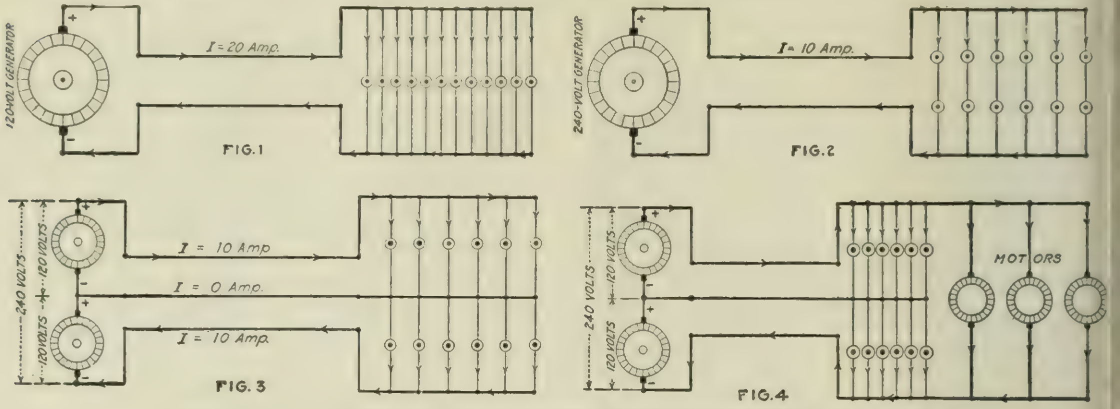


FIG. 1 FIG. 2 FIG. 3 FIG. 4

FIGS. 1 TO 4. DIAGRAMS OF TWO-WIRE AND THREE-WIRE SYSTEMS AND LOADS

While it is usual practice to make the neutral wire of the same size as the outside ones, there are cases in which it may be made smaller. If a considerable load is to be supplied with current at the higher voltage, as, for example, the motors in Fig. 4, then the size of the outside wires must be such as to safely carry the sum of the lamp and motor currents, but the neutral wire need be only of the size required to carry the lamp current, since it can never be called upon to carry more than that required by the lamps on one side of the circuit.

It might appear that when the load on a three-wire system consists of lamps used under conditions which make it certain that the load will never be unbalanced very greatly, the neutral wire may be made smaller than the outside ones, since the current through it would always be comparatively small. It must be remembered, however, that the fuse in one of the outside lines might blow, and then the neutral would have to carry as much current as the outside wire. Furthermore, the National Board of Fire Underwriters' code requires that the neutral for the three-wire load must be the same size as the outside conductors.

The percentage loss in a three-wire system is the least when the load is balanced. It is therefore necessary to distribute the lamps in such a manner that the load shall be as nearly evenly divided between the two sides at all times as possible. To show how the percentage of loss increases when the load is unbalanced, let us investigate what happens in the system of Fig. 3 when all the lamps on one side are turned off. The load remaining will then be half of what it was—namely, 1200 watts—and the current in the active outside wire and in the neutral will be 10 amperes. Suppose the resistance of each of the mains is 0.2 ohm. Then the loss in each wire will be $I^2R = (10)^2 \times 0.2 = 20$ watts, and in the two twice that, or 40 watts. The ratio of the loss to the load will therefore be $\frac{40}{1200}$, which multiplied by 100 will give the per cent. loss; that is, $\frac{40}{1200} \times 100 = 3\frac{1}{3}$ per cent. On the other hand, if the system was fully loaded we would have 10 amperes in each outside wire and no current in the neutral. The loss would therefore be the same, but the load supplied is now twice as great as before, 2400 watts, and the per cent loss is therefore $\frac{40}{2400} \times 100 = 1\frac{2}{3}$ per cent.; that is one-half of what it was before. For degrees of unbalancing between these two limits the per cent. loss will lie somewhere between the values found.

In like manner the per cent. voltage drop in the line is affected by the amount of unbalancing. Thus, when the load is balanced there is a drop in each outside wire of $IR = 10 \times 0.2 = 2$ volts, or a total drop o $2 \times 2 = 4$ volts. Since the voltage across the outside wires is 240 volts, the per cent. drop is $\frac{4}{240} \times 100 = 1$ per cent. When all the lamps on one side are turned out thereby causing 10 amperes to flow in one outside wir and in the neutral, we again have a drop of $IR = 10 \times 0.2 = 2$ volts in each of two wires, or $2 \times 2 = 4$ volt altogether. In this case, however, the lamps that ar burning are being supplied with current at 120 volts and hence the per cent. drop in voltage is $\frac{4}{120} \times 100 = 3\frac{1}{3}$ per cent.; twice what it is in the case of balance load

The problem given in the preceding lesson was to find the currents in the three lines of a 110- to 220-volt three-wire system supplying power to lamps and motors as represented in Fig. 5. The load *H* consists of eighty 50-watt and thirty 100-watt lamps, *K* consists of seventy 50-watt and fifty 100-watt lamps, and *M* consists of one ½-hp. and one 2-hp. motor, both of which are operating at 75 per cent. of full load. The load *H* would use $(80 \times 50) + (30 \times 100) = 7000$ watts, and load *K* $(70 \times 50) + (50 \times 100) = 8500$ watts. These two loads are supplied at 110 volts, consequently the currents required by them would be $\frac{7000}{110} = 63.7$ amperes and $\frac{8500}{110} = 77.3$ amperes respectively. For the motor load we multiply the horsepower output by 746 to convert it into watts. The output of each machine is stated to be 75 per cent. of its full rating. We therefore have that the total output is $(0.75 \times \frac{1}{2}) + (0.75 \times 2) = 1.875$ hp., and multiplying this by 746 we have $1.875 \times 746 = 1399$ watts. The average of the efficiencies of these motors was assumed to be 70 per cent., hence we have $0.70 \times \text{input} = \text{output}$, or $\text{input} = \frac{\text{output}}{0.70} = \frac{1399}{0.70} = 1999$ watts. Since this load is supplied at 220 volts, the current required by it will be $\frac{1999}{220} = 9.1$ amperes. The current in the outside wire *A* will be the sum of the currents of *H* and *M*—that is, $63.7 + 9.1 = 72.8$ amperes—and the current in the outside wire *B* will similarly be the sum of the currents used by *K* and *M*, or, $77.3 + 9.1 = 86.4$ amperes. The current in the neutral *N* will be the difference between the currents in *A* and *B*, which is $86.4 - 72.8 = 13.6$ amperes.

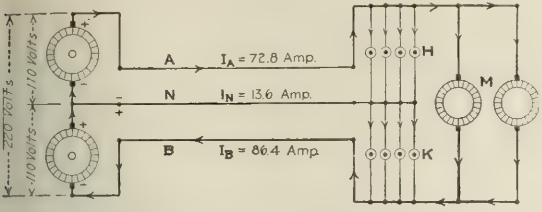


FIG. 5. THREE-WIRE LOAD CONSISTING OF LAMPS AND MOTORS

A total load of 46 kw. is to be supplied with current at 115 volts by a three-wire system. What size wire must be used for the line if the system is balanced?

Changes in Equipment Effect Savings in a Municipal Plant

By J. T. SHARP, Jr.

A municipal water and light plant makes large savings in coal by replacing old equipment and using a compound instead of a simple engine.

THE City of Canton, Mississippi, has owned and operated its water and light plant with varying degrees of success for the last 23 years. The first electrical generating outfit was a 37½-kw. alternator and a series arc machine of 40 lights capacity, belted to a Buckeye high-speed engine. There were two 100-hp. return-tubular boilers and the water-works was supplied with two 750-gal. duplex pumps. In a few years, due to flat rates, the small alternator was loaded to the place where no more lights could be taken on, and at this time there was purchased a 100-kw. alternator and an 18 x 42-in. Corliss engine and a 150-hp. water-tube boiler.

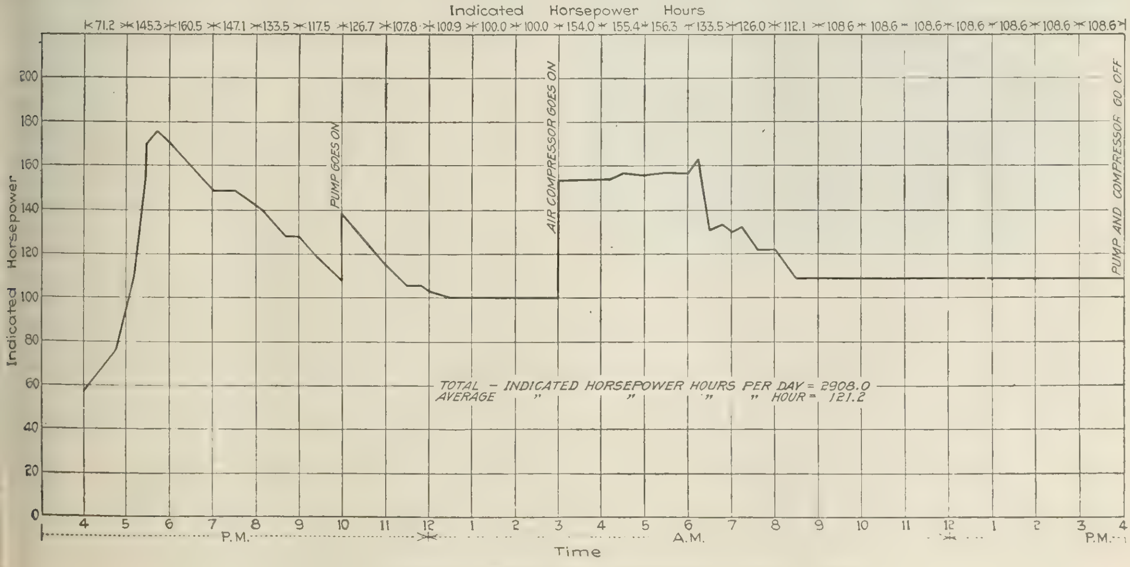


FIG. 1. LOAD CURVE OF MUNICIPAL WATER AND LIGHT PLANT

The Corliss engine as well as the Buckeye was belted to a lineshaft in the new engine room, which was provided to take care of the new equipment. The series arc machine was also used for a while until it was displaced with a modern series arc lighting system using alternating current. This lineshaft was used a number of years and was disposed of, and the Corliss was belted to a second-hand 150-kw. alternator and the Buckeye was belted to the 100-kw. machine already on hand. A small Ideal engine was bought and belted to the 37½-kw. alternator. It was about this time—early in 1906—that the service got so undependable and the expense of running the plant so great that it was decided to change the plan of management and put the plant in other hands, and it was then that the writer was put in responsible charge of the plant.

In a little while it became necessary on account of the additional amount of water used by the sewer system to use compressed air to pump the wells, and a compound two-stage air compressor was purchased, together with a 14 and 20 x 15½ x 15-in. water pump. The smaller Ideal engine was traded off and a larger engine bought and belted to a 52-kw. alternator in place of the 37½. The boiler plant at this time consisted of a 72-in. x 20-ft. 200-hp. boiler with steel setting and a 150-hp. water-tube boiler. It was deemed best on account of the age of the latter boiler and the inefficiency of the former to add another 200-hp. water-tube unit.

In December, 1913, due to the constantly increasing cost of fuel, we addressed a number of letters to various engine builders asking for quotations and guarantees on a direct-connected type of engine to be provided with belt wheels, mounted in the space usually occupied by the rotor of the direct-connected generator, and from which could be belted an alternator, an air compressor and a centrifugal pump. A log was taken of the electrical load, and the amount of compressed air needed was determined as well as the amount of water to be pumped. The correspondence covered a long period of time, and finally it narrowed down to the fact that all the manufacturers were very anxious to sell machinery, but only a single one would sell the outfit and file a bond as to the performance of the whole outfit. This company guaranteed to furnish us an 11 and 18 x 15-in. tandem compound engine, a 354-cu.ft. belted air compressor, a 500-gal. two-stage centrifugal pump, and also a 5 x 3 x 7-in. boiler-feed pump. The engine was to be belted to the compressor and pump as well as the 100-kw. alternator we already had on hand.

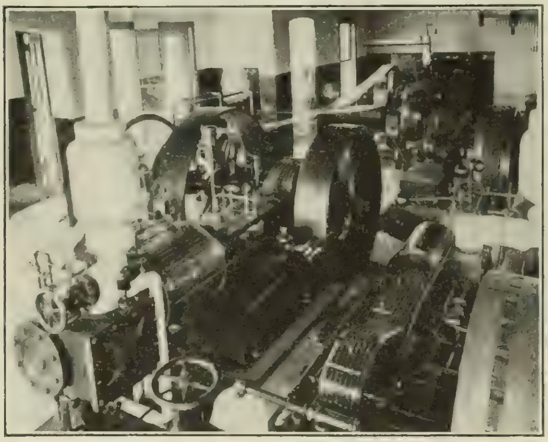


FIG. 2. VIEW OF PLANT EQUIPMENT

The contract provided that the alternator was to be run 24 hours per day on the electrical load as given and that the compressor was to be used for 14 hours per day and that the pump was to be operated for 18 hours per day. In performing the work as indicated by the load curve shown in Fig. 1 there was to be used not over 6.1 tons of mine-run coal based on the evaporation of the boiler as obtained previously with a test, which guarantee was backed up by a bond for the full delivered price of the engine.

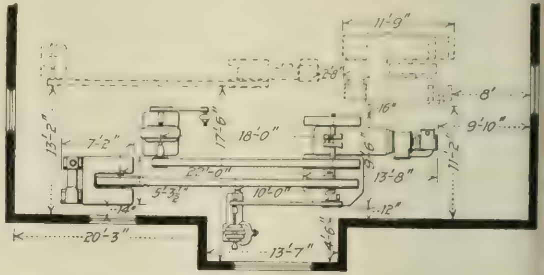


FIG. 3. ARRANGEMENT OF MACHINERY IN CANTON PLANT

A general view of the machinery is given in Fig. 2, and the arrangement of the machinery on the engine-room floor and the distances of the belt centers are shown in Fig. 3. The installation was put in and in November, 1915, was operating, although it was not put regularly into operation until Dec. 1, 1915. The new outfit came entirely up to the guarantee, and in addition to operating it, we operated the compound pump for four or five hours per day and at times it was necessary to operate the steam-driven air compressor. In spite of all of this the combined outfit still was inside the limit of coal supposed to be used on the new outfit alone. A test disclosed the fact that the new outfit was about 18 per cent. ahead of the guarantee on daily coal weights.

Our coal bill for 1915 was $8746.33 and for 1916 was $6150.48, giving a difference of $2595.85, to which will have to be added $345.14, making a total of $2940.99, or a percentage difference of 33.6 per cent. The addition of $345.14 was caused by having a raise of 10c. per ton on freight rate and the coal contractor not being able to supply us with sufficient coal, so that we were forced to buy in the open market.

For more than five years the plant has had industrial track scales and every pound of coal that is used for the plant is weighed. At the present time the new outfit is operating on a 24-hour schedule with a stop of one to two hours on Saturdays to be cleaned up and to have the bearings adjusted. During 1916 the total lost time from all causes was 1.8 per cent., and during 1917 it was 1.76 per cent. Of course this would not be a good record for a turbine, but it is certainly a good record for a reciprocating engine. The percentage of lost time covers stops on account of trouble with the air compressor, centrifugal pump, generator and engine.

At first this plant was started 133-cycle and all subsequent machines were bought 133-cycle. For the use that this town has for light and power, they fill the bill as well as 60-cycle apparatus, but as soon as the old machines are worn out it is the intention of the management to change to 60 cycles. During the last year not a minute was lost from service of night lighting by power-house troubles. All the necessary material is carried in stock to wind the armature coils when they burn out, which they do sometimes. A machine shop located in the same building next to the engine room is a part of the equipment and is very convenient when repairs have to be made.

An Adventure with "Static"

By B. J. Randall

In a large central station where I was employed as an engineer there was a fellow engineer, an inveterate practical joker, who was continually on the lookout for any jokes that we might endeavor to subject him to, and he did not always take it with good grace when we succeeded in putting something over on him.

One Sunday morning we received orders to cut the steam off from a section of the main steam line. This pipe was 14 in. in diameter, and we cut out about a hundred feet of it to repair some valves. With a pressure of 160 lb. there was considerable steam contained in this section, and the only way to bleed it was by a small valve which was reached by a ladder placed on the engine-room floor. Charley McGregor, as we will call him, was in charge of the watch at the time, and superintended the cutting-out process. When all the necessary valves were shut, he got up on the ladder to bleed the line of all pressure. This line was vertical, running through three galleries to the top fire-room, and the repair gang had taken their places directly above McGregor, waiting for him to complete his part of the work. He opened the bleeder gradually, until the steam was roaring from the line, and then descended the ladder to speak to the first assistant, who vas looking on.

"Have you got the bleeder open full, Charley?" the atter asked.

"No, but I will have it open soon," was the response, nd the speaker mounted the ladder to open the valve ome more.

The next moment, a mixture of yells and imprecations vas flooding the atmosphere. If there was one thing hat McGregor could do to perfection, it was shout nd swear, and this time he called heavily upon his ocabulary with the full strength of his powerful lungs. Ve saw him grab a large bunch of waste from his pocket nd use it to close the bleeder, and then descend the adder with a queer expression on his face.

"That line's charged," he barked. "Some smart Aleck in that repair gang must have a portable lamp grounded on it, somewhere."

"It can't be, Charley," said the boiler-room chief, who had joined us. "They haven't got any lights connected up, yet."

"Well, if you don't think I know when anything is grounded, get up there and bleed that line," snapped McGregor.

"All right. Just to show you that you're mistaken, I'll do that little thing," agreed the fire-room chief, sweetly. Mounting the ladder, he touched the valve very gingerly, in spite of his previous assertions. "See?" he said, as he felt no evidence of "juice" through the valve. "I can touch it without any trouble." And he grasped the valve wheel with his bare hand, and opened it until the steam was once more roaring into the atmosphere.

The nonplussed McGregor shook his head, far from being convinced, although he appeared doubtful of his claims. He wasn't quite satisfied with the way that the boiler-room chief had left the bleeder, and as he had seen the latter open the valve with his bare hand, he once more approached it to adjust the valve to suit himself.

"O-o-o-w-w!" he yelled, as his hand touched the valve, and then the fun commenced. Trembling with surprise and wrath, he again shut the valve with his waste, bounced down from the ladder, and swung around to glare up at the repair gang on the gallery, above.

"You blankety-blank squareheads think you are having a helluva lot of fun, don't you?" he roared, shaking his fist at the stolid-faced Swedes on the grating above him. "Cut it out, now. You've gone far enough."

Those members of the repair crew who understood him took his actions for just another of his frequent pranks, and they grinned knowingly, which incensed McGregor all the more.

We who were on the floor had not fully grasped the reasons for Charley's outburst, but we were enjoying it just the same, and all kinds of suggestions were coming thick and fast from us, to "help him" out of his difficulty.

"I don't want to touch that bleeder again until the ground is removed," he told the first assistant in a trembling voice. The latter could not conceal a smile when somebody in the bunch suggested, "You'd better change your Saturday-night brand of liquid refreshment, Charley."

McGregor's only answer was a glare that ought to have shriveled the speaker to a crisp.

The first assistant was getting impatient to have the work started, so he got up on the ladder, himself, and proceeded to open the bleeder without anything unusual happening.

"Everything feels all right to me, Charley," he said, glancing down, but "Charley" was by that time unable to think or say anything coherent.

Finally, after the steam had been drained off, and the hurriedly summoned electrician had proved that there was not the slightest suspicion of a ground on that pipeline, we suggested to McGregor that it might have been static electricity produced by the steam jet that had given him the shock. This idea mollified him somewhat, but to this day he suspects that someone in the repair gang knew more about it than anyone else.

Graphic Meters To Record Power Factor

TO CONSUMERS as well as producers of electrical energy the importance of records of power factor is universally recognized. The power factor directly affects the size of conductors, the capacity of equipment, the efficiency of a power installation and the voltage regulation. The correction of low power factor and the resultant economies in power costs, increased production and better voltage regulation can be accomplished only after complete information and accurate records of power factors have been secured. To truly represent conditions records must be taken continuously over a sufficient period of time to include a complete cycle in the operations being performed. In the past records of this character were secured by means of an observer reading indicating instruments and plotting the values on cross-section paper in order to secure a graphic representation of the changes that took place.

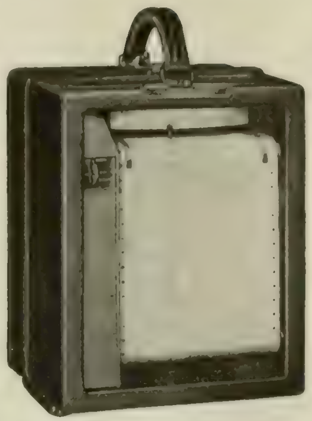


FIG. 1. PORTABLE GRAPHIC POWER-FACTOR METER

Graphic-recording power factor instruments of the portable, switchboard and wall types, made by the Esterline Co., of Indianapolis, are now available. The switchboard type of instrument is intended for permanent installation on switchboards in power plants, substations, and on the properties of large power users having distributing switchboards. The wall type of meter is designed to be mounted on any flat vertical surface to record the power factor of the electrical apparatus to which it may be connected. This type is most suitable for a permanent installation on consumers' premises. The portable instrument, Fig. 1, is compact in design, and by the use of aluminum in the construction of the case and other parts the weight has been reduced to 17 lb. This instrument is especially suitable for general power-survey work, and in making tests on individual motors, groups and complete installations. In all of these instruments the movements are of the dynamometer type, no iron being employed in the magnetic circuits and no inductance or capacity used in the electrical circuits, so that the instruments are free from the effect of varying frequency and wave form.

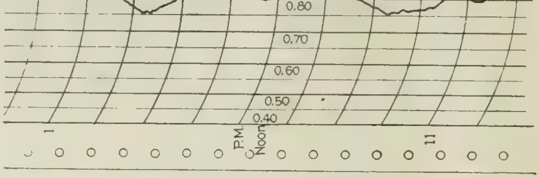


FIG. 2. GRAPHIC CHART OF RECORDING POWER-FACTOR METER

Among the features showing improvements over previous models are the elimination of jewels, pivots and hair springs, a removable pen element, a movement frame molded from bakelite, inclosed nonspillable inkwell and oil damper molded integral with the frame.

During construction each part of the instrument is subjected to an insulation test of 11 volts between current-carrying pa and the support, and after the inst ment is completely assembled and ca brated it is again subjected to the co tinuous application of 1100 vol between current-carrying parts and t frame for a period of one minute. oil damper designed to be nonspillal is provided to damp the movement the pointer where the characteristics the circuit make it desirable. A featu to be noticed is that the pen is mount upon and is actuated directly by t measuring element of the meter, wh the ink supply is stationary. This e ables the instrument to follow quick fluctuations in power factor witho the use of the usual limiting devic The entire writing element is carri on knife-edges and can be lifted out for filling a cleaning.

Record charts, Fig. 2, have a ruled portion 4½ i wide. They are graduated from 40 per cent. power fa tor at the left-hand edge to 100 per cent. at the righ hand side of the chart, the usual range of power fact encountered coming near the center of the chart. Th standard chart speed is 3 in. per hour, but chart spee of ¾, 1½, 3, 6 and 12 in. per hour can be supplied. Whe it is desirable to record rapid fluctuations in power fa tor, minute chart speeds can be supplied by equippin the clock with a rapid chart-feeding device, makin available speeds of ¾, 1½, 3 and 6 in. per minute in add tion to the regular hourly speeds. The clocks are of th marine, lever type, eight-day movement, contained i dust-tight metal cases.

Instruments with a nominal voltage rating of 100, 20 or 500 volts are furnishe All current coils are de signed for a nominal cu rent capacity of 5 ampere Separate voltage mult pliers permit the use 100-volt power factor in struments on a 200- or 500-volt circuit, this fea ture being especially de sirable in a portable in strument used on a syster having a number of volt ages. Polyphase graphi recording power-factor in struments require two po tential circuits and on current circuit. Whe used on circuits having current capacity exceeding 5 amperes, a current trans former is required, and when the potential exceeds 65 volts two potential transformers should be used.

The most satisfactory way to clean a furnace is th one that is easiest, quickest and most efficient.

EDITORIALS

Efficiency in Our Merchant Marine

WE AMERICANS have appropriated many millions for the construction of a merchant marine. Ve have started from zero. Once we cut quite a figure n world shipping, but that day has long since passed. One's father was not in the thick of it, but one's grandfather may have been. This gives one an intimate idea of how long ago it was that the Stars and Stripes partly filled the void between sea and sky about the world and how little the present generation of Americans know about the ways of world sea traffic as such knowledge s had from the deck and hold of a ship.

Now if we are to make this enormous investment pay ts own expenses, to say nothing of realizing a fair profit, we must do some tall thinking and get some ypically American action. The American has a standard of living that makes the rest of the world look like he familiar Sicilian laborer who munches his huge bread loaf and raw onion two paces from the scene of his toi! It will require a considerable part of the operating sum to keep the human side of our ships in good humor and willingly capable. From the standpoint of labor costs we are at a woeful disadvantage with the world.

It must not be imagined that we can make a living arrying the other fellow's goods to the four corners of the world. He has been carrying his own and ours for many years; he is on the ground floor with rates hat likely will put ours to shame unless we can outlass him from other directions. And world-beating efficiency in the production of goods shipped in American bottoms must not be called upon to assist in paying he freight. The same ingenuity and engineering that make quantity and quality production of our commodities the wonder and study of the world must permeate our whole shipping activities from the shipyard to the delivery of the cargo.

Fortunately, we are starting from zero. We already have made excellent progress in finding and adopting he most efficient in construction and equipment. The many forces at North Broad Street, Philadelphia, have covered more ground than the public appreciate. We are not, it is hoped, to be burdened with traditional lost notion or prejudice. We lost our hold on the sea because of this very thing. We just pinned our faith to he sail and wooden ship and held aloof from the steel and steam craft until, when we came to our senses, we were hopelessly adrift.

Not the least among the things we must do besides getting construction costs down, is to get operating costs to a competing level. American ships must have a type of boiler that will outclass anything afloat. Not only must it have the most efficient heating surface, but the furnace should be made to produce an efficiency relatively equivalent to that obtained in modern land boilers. This cannot be done with the Scotch boiler. Investigations of combustion and heat transmission in the new Bell Emergency Fleet water-tube boiler and in the first Emergency Fleet boiler, conducted jointly by the Emergency Fleet Corporation and the Bureau of Mines, have shown that with but a few changes in air supply and distribution the combined efficiency may be increased something like eight per cent. above the usual. An evaporation of eight pounds of water per square foot of heating surface is had even at this early stage of experimentation.

Bone's results with surface combustion as well as boiler practice in this country show that combustion volume is of far less importance than provisions for thoroughly mixing the gases of combustion with the air supporting combustion. In land practice large combustion volume is the cheapest way of promoting this mixture. There is not headroom for such volume aboard ship; complete mixing must be had otherwise. And it may be easily and conveniently accomplished—in fact the Emergency Fleet Corporation and the Bureau of Mines engineers already have achieved it.

Hand stoking aboard American ships should be eliminated. Here again these engineers are confident they can develop a suitable stoker. For efficiency in the combustion of liquid fuels, particularly fuel oil, the American naval engineer is the best-versed man on all the seas. He must show our merchant marine how to do it. Here, again, the Bureau of Mines can help greatly with its excellent talent, methods and experience in temperature determinations and its knowledge of heat transfer and the behavior of furnace gases.

There are, perhaps, reasons to believe that it is the training of the human side of these merchant ships that will need closer attention for the longest time. The constructional and mechanical sides are more stable. There does not seem to be grounds for the oft-repeated statement that American young men do not care for the sea. Henry Howard, Director of Recruiting Service, and his colleagues have done some excellent pioneer work in the training of men for our merchant marine. No matter by whom done, or where, there should be maintained some practical organization for this purpose. If we plan superior equipment for ships, we must plan equally well to train the deck and engineer officers and men who will man them.

Metering the Air Supply to the Furnace

NOT long ago, in an editorial commenting on the difficulty of measuring the air supplied for combustion, the statement was made that no satisfactory method has yet been devised whereby a definite quantity of air, by volume or by weight, can be metered on its way into the furnace. It was pointed out that the weighing of the air by automatic scales, as is the case with coal, or the measurement of it in cubic feet, as is the case with feed water, is not feasible.

Exception to this statement has been taken by one of our readers on the ground that it ignores at least one form of boiler-control apparatus in which the measurement of air flow through the boiler passages plays an important part; and as other readers may have had the same view, it is advisable that we should disclaim any intention to minimize the value of that particular instrument or of any other similar form of boiler-control device.

The apparatus to which our contributor calls attention makes use of the difference of pressure between the furnace and the uptake to measure the rate at which the air flows through the boiler passages, and this rate of flow is graphically recorded on a chart, together with a record of the rate of steam generation. The firing is so regulated as to make the rate of air flow follow closely the demand for steam, on the logical assumption that for every pound of air admitted to the furnace there should be a definite quantity of steam generated under certain predetermined conditions.

In the control of a boiler fitted with a meter of this type, therefore, the object to be attained is an approximate paralleling of the curves recording the rate of steam generation and the rate of air flow. The steam flow is easily recorded in pounds per hour by the use of an accurate meter, but the flow of air is recorded in its relation to the steam flow instead of in pounds or cubic feet.

Just what this relation should be, to obtain the most economical results, is first found by a boiler test and the meter is adjusted accordingly. It will be noted that at no time is the fireman aware of the quantity of air, in pounds or cubic feet, entering the furnace. But by the relative positions of the recorded curves he knows whether too much or too little air is being used, and that is the information that is of importance to him in the management of his fires.

The Evolution of Intensive Power

WE FREQUENTLY hear such remarks as "wonderful power," "tremendous force," etc., and we stand in awe as we contemplate the potentialities of a gigantic hydro-electric plant or a modern central station. A moment's thinking leads to the conclusion that the power itself is not what puts us into this state of mind, but rather what man has done in his effort to harness power and make it work for him. Power has resided in the elements since the dawn of creation. Man's problem since that time has been to find a more and still more intensive means of employing power for his own benefit. The way in which man has mobilized and mechanically ordered the free natural forces from which power is derived arouses our deepest respect and admiration. Power is limited only by the extent to which man uses his constructive imagination. The wooden waterwheel of yesterday is the hydro-electric turbine of today. From the teakettle of Watt has been evolved the two thousand-horsepower boiler of 1919.

In order to permit this development, materials and processes have had to be perfected. The small iron or copper plates of which the haystack boilers of Boulton & Watt were constructed have given place to steel plates of a length, width and thickness the possibility of the production of which Watt could not have conceived. Tubes and pipes laboriously welded by hand over mandrels have paved the way to modern steel tubular products which include diameters from one-eighth inch to thirty inches, and lengths up to forty feet. By the invention of material with high tensile strength and its ingenious adaptation to the lines of force, the eighty-eight feet per second allowable speed of the old flywheel has become the one thousand feet per second of the modern turbine.

Power is the same old servant that it always has been, but man, with his inventiveness and imagination and enterprising spirit, has made it do work that would otherwise have required millions of men and to perform services that it would have been impossible for man to perform

There is in the ordinary design of boiler setting about four per cent. heat loss through the furnace walls More than one engineer has wondered why the walls of boiler settings are so frequently made with an air space because, although the air in the space is a poor conductor, heat from the furnace passes through it rapidly by radiation. Why not make settings solid and cover them on the outside with some sort of insulating material?

Public interest in many industries has been awakened by moving pictures showing processes from raw materials to finished products. A set of films, beginning with the origin of fuel and carried through the construction, erection and operation of a power plant t one of the common applications of power, would afford popular instruction and entertainment, besides stimulating interest in power engineering, of which the average person is woefully ignorant.

Steam-pipe systems should be laid out with care, s that expansion and contraction strains may be taken care of. Notwithstanding this fact one observes numerous instances where pipe lines are rigidly constructed and the expansive force tends to either throw the engine cylinder to one side or to turn the pipe connection at the boiler nozzle. Is it any wonder that ther are leaky joints?

A 25,000-kilowatt generator in Chicago is rewound to give 35,000 kilowatts and the hand-fired boilers in another plant are raised several feet and equipped with stokers giving them a hundred per cent. more and badly needed capacity. Talk about intensive farming

With all the attention welding is receiving these day maybe something besides making welds and pulling them in the old way will be done in an effort to discove a means to determine their strength and characte without testing them to destruction.

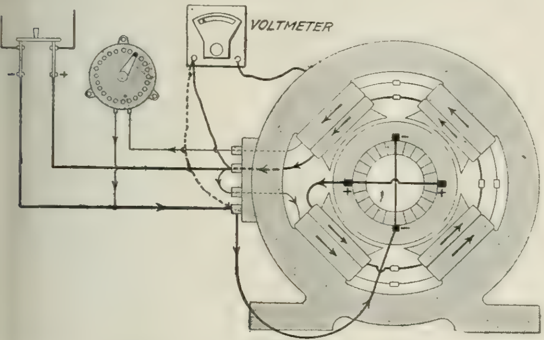
It is foolish to lose sight of the fact that by far th greater number of men in the United States are worker to whom a skilled hand is as important as a well developed brain.

A rolling stone may not gather any moss, but several engineers are convinced that a revolving turbine roto can pick up a lot of salt on occasions.

CORRESPONDENCE

Generator Heats Excessively

In the Jan. 21 issue of *Power* Peter Burkard, writing nder the title, "Generator Heats Excessively," states hat his 160-ampere direct-current generator operates at xcessive temperatures when carrying only 90-ampere oad. This can happen from a number of causes, but ust what does Mr. Burkard mean by excessive temerature? Is it something he considers excessive by he feel of the machine when touching with the hand, r have actual temperature measurements been made nd the hottest spots on the winding, as measured with thermometer, been found to exceed 175 deg. F.? Temeratures that are well within the allowable range feel ecidedly uncomfortable to the hand. Consequently, achines are sometimes considered as operating at a igh temperature, when in fact if temperature measureents were taken they would show that the machine as well within safe limits.



METHOD OF TESTING INSULATION

It has not infrequently occurred that the switchboard mmeter indicated that the machine was operating nder only partial load, when the truth of the matter as it was overloaded and the ammeter was reading ow. Therefore it would be well for Mr. Burkard to heck his instruments if he has not already done so. e intimates that the high-resistance brushes might e causing the trouble, although they do not heat xcessively. The brushes cannot be the seat of the ifficulty or they and the commutator would be the ottest parts of the machine.

If the installation is an old one, high temperature ay be caused by current leaks through the insulation. he condition of the insulation may be easily deterined by getting the machine up to full voltage and onnecting one terminal of a voltmeter to the frame nd the other terminal of the instrument to one of he armature terminals and then to the other, as in he figure. In no case should the instrument read ore than 3 or 4 volts.

The spacing of the brushes on the commutator may e the cause of the trouble. Unequally spaced brushes ften produce heavy circulating currents, especially if the brushes have a low resistance. However, in this case since the brushes are operating at a low temperature it does not appear as though circulating currents caused the trouble. B. A. BRIGGS.

Chicago, Ill.

Constant-Potential Transformer Used as a Series Transformer

At several locations in our series street-lighting system there are series transformers of a 1 to 1 ratio serving as safety coils for special lighting. Several of these transformers have been burned out by lightning, and on account of the difficulty in getting others in time we were forced to rewind the damaged unit in some instances, and in others a temporary substitute was used until new transformers could be secured. The series transformers were insulated to withstand 5000 volts between the primary and secondary coils and also between the winding connected to the high-voltage circuit and the core.

In so far as ratio is concerned, any potential transformer having two coils of a 1 to 1 ratio and of sufficient current capacity can be used as a series transformer, but on account of the insulation requirements between the coils a special selection must be made. No transformer can be used that has the sections of each half of the secondary winding adjacent on the core, on account of low insulation resistance between them. This is to be found in some core-type transformers having a secondary coil subdivided and grouped on the two legs of the core and cross-connected in such a way as to make three-wire operation practical.

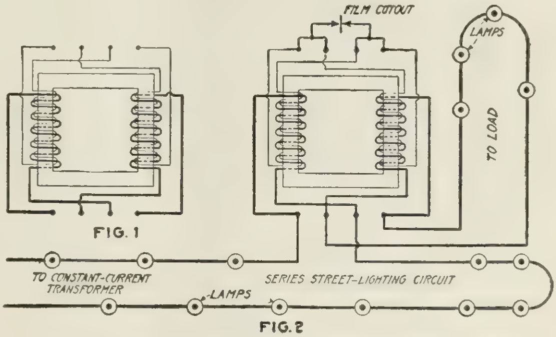


FIG. 1
FILM CUTOUT
LAMPS
TO LOAD
TO CONSTANT-CURRENT TRANSFORMER
SERIES STREET-LIGHTING CIRCUIT
LAMPS
FIG. 2

FIGS. 1 AND 2. POTENTIAL TRANSFORMER AND CONNECTIONS AS SERIES TRANSFORMER

For use as a series transformer, I selected an old core-type potential transformer having two 1100-volt primary coils, one on each leg of the core, and located next to the iron. The two 55-volt secondary coils were also located one on each leg of the core and outside of the primary coils, as shown in Fig. 1. The insulation resistance was tested with 10,000 volts between primary and secondary, and primary and core. A test was also made with 5000 volts between the two sections of the secondary winding and the secondary winding and core.

By using the secondary on one leg of the core as a primary and connecting it into the high-voltage series circuit, and using the secondary coil on the other leg of the core as a secondary and connecting it to the load as in Fig. 2, a series transformer with a ratio of 1 to 1 was obtained. In order to overcome the effect of magnetic leakage on the ratio of transformation when used as a series transformer, the primary coils were connected in parallel, as shown in Fig. 2.

The iron in the regular series transformer was worked at a high degree of saturation, thus making the use of a film cutout in the load side unnecessary. However, in the case of the potential transformer used as a series transformer, the film cutout was necessary on account of the core being worked at a low magnetic density, and there would be a large voltage rise in the high-voltage coils in the event of an open-circuit in the load circuit, which would damage the insulation of the coils. The film cutout was connected in on the high-voltage coils as in Fig. 2.

On account of the weight and cost, such transformers should be used only in an emergency, as in the case in question. The weak points in this equipment are in the secondary bushings and leads, where they come through the case. The bushings should be wiped clean and the leads made to clear one another and also the case, after which no trouble will be found in use up to 5000 volts. For use on higher voltages constant-potential transformers having sufficient current and voltage capacity in the high-voltage coils could be used. The low-voltage coils should be connected in parallel in this case and a film cutout connected across the coil connected to the load. HENRY MULFORD.

Patchogue, L. I., N. Y.

Speed Loss in Transmission

We have several machines that are run from the same lineshaft, all with the same combinations of pulleys, but owing to lost motion or slippage of belts the total output of the different machines varied considerably during the day's run. This caused dissatisfaction among the operators who were on piecework, each wanting the fastest machine.

To equalize the speeds of all the machines, we riveted leather of the necessary thickness on the face of the driving pulleys, equalizing the speed to make the output of each machine the same. C. B. BRUSH.

New York City.

Overheating Hot Water Wasteful

Considerable coal can be saved by the proper regulation of the hot-water supply to buildings. There is no economy in drawing a quantity of hot water and then cooling it by the addition of cold water. About the only thing that real hot water is needed for in hotels, apartment houses, etc., is in kitchens, for washing greasy dishes, etc.

In order to meet these requirements in one building that I know of, all the kitchen sinks were equipped with a steam pipe through which steam can be blown to boil the water. The thermostat on the hot-wate tank was then set for about 40 deg. lower temperatur than previously carried and there was no complain from anyone in the building excepting from an ol lady who complained that she could no longer make he tea with the hot water. She was advised to get a gas o electric heater because the water would never be kep so hot again. W. T. MEINZER.

Brooklyn, N. Y.

Constant Pressure with Mixed Coal

The accompanying chart is one of many taken fror our steam-recording gage on a 150-hp. return-tubula boiler, hand-fired, with natural draft and burning mixture of hard and soft coal with the proportion o one part of barley to two parts of bituminous coal. I will be seen that there is no perceptible variation in th steam line except at 3:15 p.m., 10:15 p.m., and 5:15 a.m The fires were cleaned once on each of the three shifts the chart being the record of three firemen.

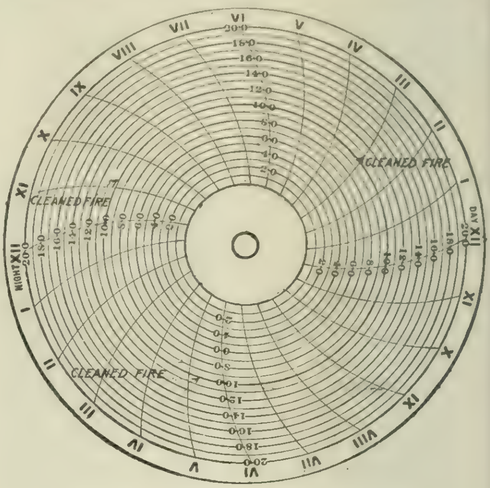


CHART RECORDING HAND FIRING

Ventnor City, N. J. E. H. GASKILL.

Testing Cylinder Oils

In reference to Professor Trinks' suggestion in th issue of Oct. 29, 1918, page 644, I have found th steam-engine indicator a splendid instrument for testin cylinder oils. I made this discovery some 12 years ag while conducting some engine tests. I found tha straight mineral cylinder oil can be detected with th indicator, as it will cause irregular lines on the diagram My subsequent experience in seven different plants wit quite a variety of engines convinces me that a straigh mineral oil will always produce this effect, which i proof of improper lubrication. In one case a chief engineer rejected cylinder oil that contained 5 per cent of animal oil and accepted a straight mineral oil large because it cost less than half as much per gallon. Thi saved about $60 in four months, but injured the engine to such an extent that the service was interrupted total of over 17 hours in one week and the enginee lost his job. Moreover, it required the expenditure o

.80 to repair the engines, not including labor, which ounted to perhaps as much more.

iscosity, fire and many other tests are unsatisfac- y when it comes to cylinder oils. A high-grade nnsylvania stock compounded with about 5 per cent. d-free animal or tallow oil will keep engines running oothly and keep the engineer out of trouble. Follow- are the specifications for an oil that I have used years with entire satisfaction: Pennsylvania am-refined cylinder stock, gravity 24.5, flash 586 ., fire test 665 deg., viscosity 137 at 212 deg., price . per gallon, which includes 5 per cent. clean acidless low oil mixed by air agitation.

ne contributor suggests that cylinder oils be tested pumps. I have not found this a satisfactory test, almost any oil will do for small pumps because the am pressure and piston speed are usually low and valves are easy to lubricate, which is seldom true engines. Low-pressure cylinders will give less uble if high-grade cylinder oil is mixed with two rts of filtered engine oil. The drips from tail rods be utilized in this mixture to good advantage.

A frequent cause of difficulty in cylinder lubrication from rust or sweat corrosion while the engine is nding idle, but the greater part is due to the use soda-ash boiler compounds or water-softening systems which an excess of soda ash is used. Soda ash will ays destroy cylinder lubrication. Another point sel- n given consideration in cylinder lubrication is ether the boilers prime or not, and this is a very portant factor in comparing one plant with another. elieve engineers should use more common sense and s fad stuff and snap judgment in the study of lubri- ion, for what is successful in one plant may not be another. **Waldo Weaver.**

ranklin, Ohio.

Motor Suddenly Reversed

hat a 3-hp. 110-volt shunt-wound motor could re- se under the condition that John R. Steeska describes the Jan. 21 issue of *Power* seems impossible if the tor has any protection against overloads at all. The eds given, 2200 to 2800 r.p.m., I take it are the -load and no-load speeds, which would be a speed iation from no-load to full-load of 21.4 per cent. is is abnormally high for the average commercial chine and would allow the motor to take only ap- ximately 4.5 times full-load current with the arma- e locked. Even at this, if the motor was properly tected, the protection device should open before the tor could come to rest due to an excessive overload otherwise.

here are two things that might happen to cause the chine to reverse: First, the field circuit to open h the brushes set back of the neutral (operating h the brushes back of the neutral is a common ctice on motors without interpoles); second, the shes set back of the neutral and the machine sub- ted to a heavy overload of short duration.

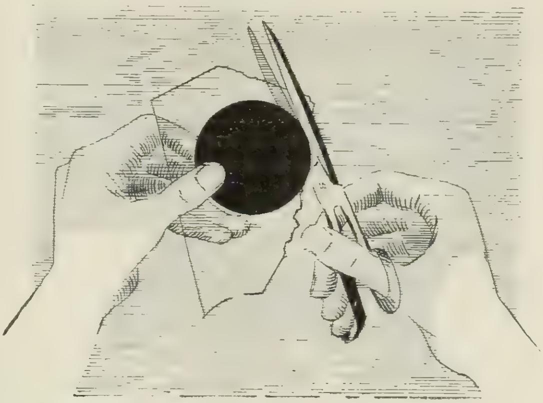
f the armature resistance is as high as indicated the speed variation from no-load to full-load, the shes may be set considerably back of the neutral yet operate satisfactorily. Therefore I feel that the best explanation for this phenomenon is, that a heavy overload was thrown on the motor by someone putting excessive pressure on the buffer, causing the motor to slow down, the brushes being set far enough back of the neutral to cause the armature poles to reverse the polarity of the field poles and reverse the direction of rotation. This of course could not happen if the motor was properly protected.

Another thing that could cause the motor to reverse is, the brush-holder working loose and shifting around the commutator far enough to reverse the direction of the current through the armature. However, this could not occur without the cause of the trouble being discovered before the machine could again be put into service.

New York City. **A. A. Fredericks.**

Cutting Glass Under Water

Cutting a glass dial with a pair of scissors may seem difficult, but it is not, although the job must be done under water and both the glass and scissors must be submerged. A good way is to first cut a paper the size or shape of the glass desired; place it on the under side of the glass for a pattern. It is not expected that it is possible to cut through the center of a large piece of glass, but by trimming a little at a time a good job can be done. The cutting sensation is a good deal the same as that of cutting cardboard. **A. Dube.**



CUTTING GLASS UNDER WATER

Burke, Idaho.

Boiler Horsepower from Metered Condensation

With reference to the item on "Boiler Horsepower from Metered Condensation" in the issue of Dec. 31, 1918, to which I took exception on Page 101, Jan. 21, my remarks were the result of long and wide experience, and while the editor states that he is always glad to publish discussion letters, I object to the bracketed remarks sprinkled through my comment on the subject quite as much as I would frequent interruptions were I talking on an interesting question. And this subject is of interest to a great many besides the gentleman who originally asked the question, his particular case being covered by my remark that "steam is not generally sold on the B.t.u. basis," while my opening sentence dispelled any question as to the correctness of the editor's reply and did not ask proofs as illustrated by the fact that I used both the equivalent evaporation figures which you mention and which are known to most engineers before they go to college.

I would like to ask if you, Mr. Editor, have considered the first cost, the installation cost and the maintenance cost of the devices that would be required to sell steam on an accurate B.t.u. basis, and also to have you tell me what to install to sell my steam to tenants and have proofs to combat any disputed charges. Has it not been proved by all the big central steam stations such as the New York Steam Co. that it is impossible to accurately sell steam on a B.t.u. basis? For a basis of calculation consider that I am operating a five-story loft building, that our steam pressure varies from 80 to 125 lb., that we have three 100-hp. boilers, but cannot hold the pressure constant owing to load fluctuations. Would you advocate a recording thermometer on each tenant's return, or on the outlet of each machine where the power of the purchased steam is consumed, or at the inlet, or outlet, of the condensation meter, and where should the meter be placed? Again, would it not be fairer to obtain temperature as it is returned to the point of reconversion?

Your answer to the foregoing will be of great assistance in solving many questions and disputes on the subject and be of interest to two well-known readers of your paper who at present are also very much interested in this subject. THEODORE HAIGHT.

New York City.

Pump Valves Do Not Wear Well

The inquiry by M. C. Larsen on page 30 in the issue of Jan. 7 and the letter on page 101, Jan. 21, commenting on the breakage of rubber pump valves calls to mind a condition that existed in a certain power plant a few years ago. The feed-water temperature varied from about 60 to 212 deg. The cause was that normally the exhaust from the main engines was sold for manufacturing purposes, the condensate being returned at a temperature of approximately 190 deg. and the remainder of the heat necessary to bring it to 212 deg. being supplied by an open feed-water heater that was too small to heat all cold water to that temperature. Consequently, when the supply of hot water was interrupted, which occurred a number of times each day, the feed temperature in winter dropped to about 60 deg. This caused the rubber pump valves to break into small parts, some of which passed over with the feed water and lodged in the 2-in. globe valves used for boiler feeding. As a result these valves required frequent cleaning and on a few occasions caused serious trouble.

As suggested by Mr. Molloy, the solution lay in metal valves, which I installed soon after taking charge. In this case, however, the valves were fitted with a narrow strip of soft composition resembling rawhide, which served equally well for hot and cold water, and were not as likely to leak as all-metal valves. At the time I left that plant, the valves had been in service about two years and had given no trouble whatever.

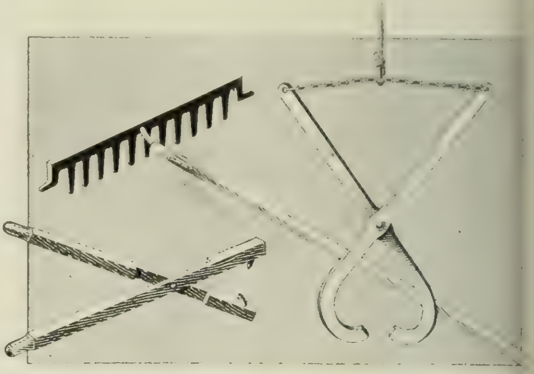
Holyoke, Mass. C. B. HUDSON.

Handy Tools for the Water-Power Plan

Many readers of *Power* are no doubt operators hydro-electric generating plants and have to conter with various perplexing problems, one of which is t leaf and ice gorge. The leaf gorge occurs at vario times, beginning with the first fall of leaves in t autumn and recurring as each "high water" rises higher levels along the river banks, thus reachi leaves deposited at those levels.

Troubles from ice may be due to surface or cake or to frazil or anchor ice. The illustration sho three devices that have proved their worth.

One is a modified rake used for pulling leaves fro the trash racks, made by bending the two outsi teeth at right angles to the others so that the tee of the rake are allowed to slip in between the ba of the trash rack only the desired distance, and th distance is made less than that from the outer ed of the rack bar to the bolts that hold the rack t gether. This arrangement eliminates the chances the teeth catching the bolts that hold the bars.



HOME-MADE TOOLS FOR WATER-POWER PLANT

Another handy tool is an ice hook that was quick made in an emergency and serves its purpose a mirably. It is used to pull from the racks cakes ice that would otherwise be difficult to dislodge. It made of two pieces of wood bolted together as show The long ends are used as handles, and in the oth ends sharpened spikes are driven. When the ice too heavy to handle with this device, regular i tongs are used with a rope to a tackle block.

Richmond, Va. JAMES M. PURCELL.

Conditional Acceptances of Equipment

BY A. L. H. STREET

Plaintiff sold two automatic boiler cleaners to d fendant under a contract providing for a 60 days' tria and providing that if the equipment should prove to satisfactory the defendant would honor draft for t price 60 days after the installation. It was agree that if the cleaners should not work satisfactorily t defendant would so notify plaintiff in writing, affordin the latter opportunity to make the appliances satisfa tory. Defendant gave no intimation of dissatisfactio within the 60-day period. Under these circumstanc it is held by the Kansas Supreme Court that defendant obligation to pay the purchase price became absolute.

INQUIRIES OF GENERAL INTEREST

Varying the Speed of Wound-Rotor Motor—Is it practical vary the speed in a ratio of 3 or 4 to 1 of a wound-rotor luction motor, by varying the rotor's resistance? T. A.

The speed can be reduced in this ratio but it is not pracal on account of the unstable operating condition of the tor at such reduced speeds, and the motor's efficiency will o be very low, since 75 or 80 per cent. of the total energy ken by the motor is expended in the rotor's external sistance.

Wiredrawing of Steam—What is wiredrawing of steam? n any form of pressure-reducing valve operate without redrawing? A. P.

The term "wiredrawing" is applied to the operation of charging steam through an aperture or passage, but most commonly employed with reference to a constricn of the flow that results in sudden increase of velocity e to the discharge taking place from a higher to a lower essure. The very operation of a pressure-reducing valve to automatically adapt the discharge aperture to the e of opening required for the flow necessary to sustain e desired pressure on the low-pressure side compatible th the difference of pressure. A reduction of pressure the steam in passing through the valve must be accomnied by velocity due to the difference of pressure, and any flow to take place there must be some degree of redrawing.

Piston Speed of Pumps—What should be the maximum ton speed for pumps of various lengths of stroke up to in.? J. S. M.

The maximum speed without undue slippage is limited inly by the time required for the valves to seat propy, which depends on the number, type and size of the lves and number of reversals per minute. For pumps good design, and ordinary ratio of diameter to stroke, e following speeds may be regarded as the maximum for od operation:

PISTON SPEEDS, FEET PER MINUTE

Stroke, Inches	Ordinary Service, Feet per Minute	Boiler Feeding, Feet per Minute
3	40	20
4	50	25
5	60	30
6	65	33
8	75	38
10	80	40
12	90	45
15	100	50

Required Cutoff for Different Initial Pressure—An autotic noncondensing engine 20 x 16 in., running 208 r.p.m., supplied with steam at an initial cylinder pressure of lb. gage and cuts off at 25 per cent. of the stroke when rying rated load. What will be the point of cutting off the same load when the initial pressure is 70 lb. gage? E. J. W.

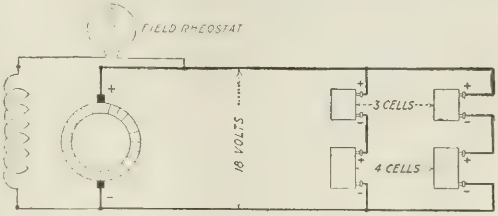
For the same load and speed, the length of cutoff must appropriate for obtaining the same m.e.p., and that pends on the initial pressure, per cent. of cylinder clearce space and back pressure. The formula for finding e average absolute forward pressure for 1 lb. absolute tial pressure is:

$$P = (1 + log_e\ R)\ (f + c) - c$$

which $P =$ average forward pressure per pound absolute; $=$ ratio of expansion $= (1 + c) \div (c + f)$; $f =$ per nt. of cutoff; and $c =$ per cent. of clearance. Allowing per cent. clearance and 25 per cent. cutoff, the formula uld give $P = 0.6359$, and the forward pressure for an tial pressure of 90 lb. gage, which is equal to an absoce pressure of about 90 + 15 = 105 lb. absolute, would be 359 × 105 = 66.77. The m.e.p. would be the average rward pressure minus the average back pressure. Asming, for example, the average back pressure, including compression, to be 30 lb. absolute, the net m.e.p. would be 66.77 − 30 = 36.77 lb. Assuming any different back pressure as 28 lb., in the case of an initial pressure of 70 + 15 = 85 lb. absolute, the average absolute forward pressure would need to be 36.77 + 28 = 64.77 lb., and the cutoff would be at a fraction of stroke giving 64.77 ÷ 85 = 0.762 lb. average forward pressure per pound initial absolute. With this value of P, the value of f in the formula can be found by assuming different values of R. But in place of such a tedious operation, we may turn to a table of mean pressures per pound of initial, with different clearances and points of cutoff, such as given on page 115 of Low's "Steam Engine Indicator," which gives as the nearest an average pressure of 0.7646 for 7 per cent. clearance for cutoff at $\frac{3}{8}$ of the stroke.

Charging Storage Batteries—Can a small direct-current generator that has a voltage range up to 25 volts be used to charge two 3-cell and two 4-cell storage batteries? R. G.

If the generator has sufficient current capacity without overheating, it may be used to charge the batteries. However, it will be necessary to connect one 3-cell battery in series with a 4-cell battery and connect the two groups across the generator, as indicated in the figure, or one group may be charged at a time. It will require about 18 volts to bring the groups up to full charge. This voltage can be obtained by an adjustable rheostat in the field circuit, as shown. A group of two 3-cell batteries, connected in series, can be charged alone and will require about 10 volts; a group of two 4-cell batteries connected in series can be charged alone, and will require about 21 volts. The foregoing statements are based on the assumption that the batteries have the same ampere-hour capacity.



Speed of Engine Required to Develop Given Power—What speed would be necessary for a 14 x 16-in. slide-valve engine, with throttling governor, to develop 100 i.hp., if supplied with steam at 100 lb. pressure? E. T.

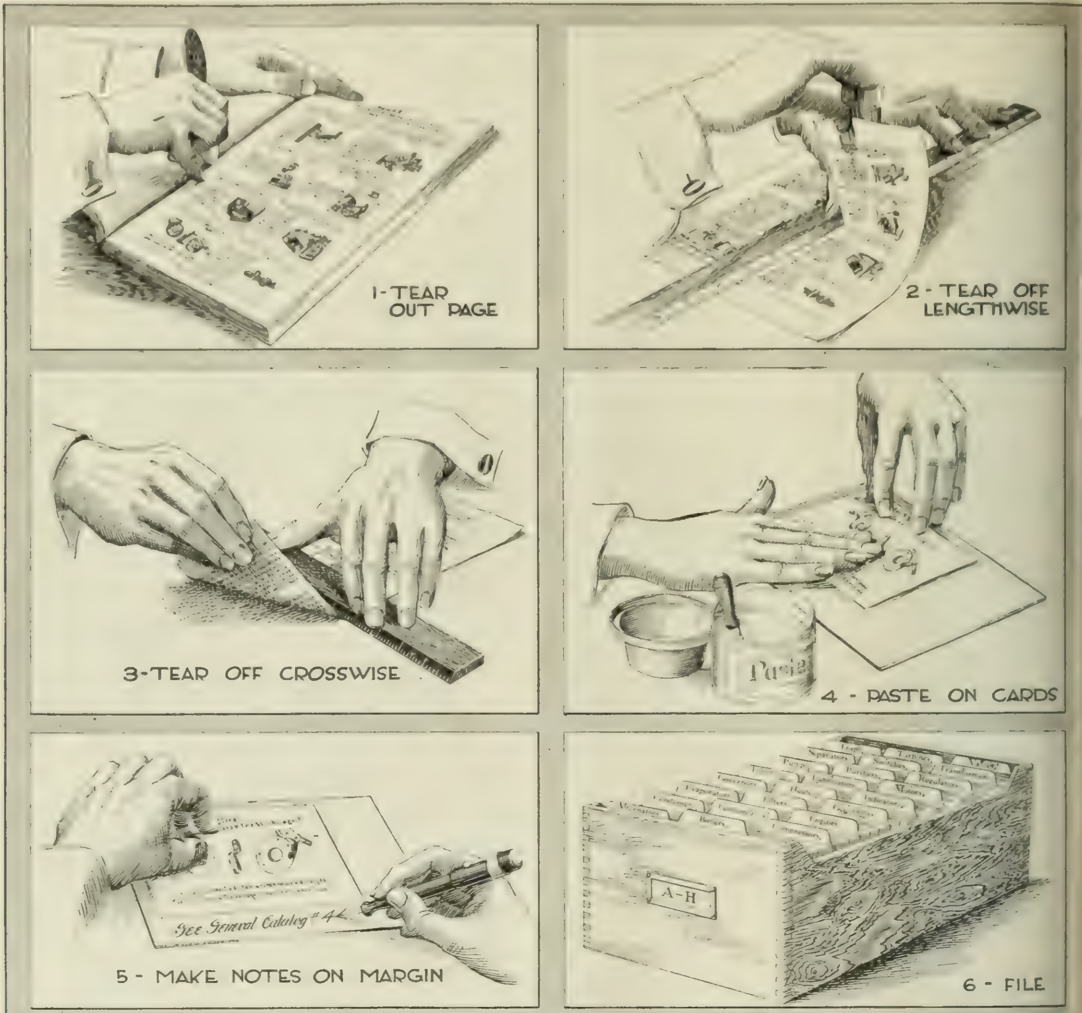
The highest mean effective pressure, and consequently the most power obtainable, would depend on the design, size and working condition of the throttling governor, the steam-chest pressure realized, the dimensions of the valve, ports and passages, the amount of lead, points of cutoff and compression, as determined by the valve design and setting, and the amount of back pressure on the exhaust. With cutoff at about $\frac{3}{4}$ of the stroke, 2 to 3 lb. back pressure on the exhaust and enough compression of the exhaust for smooth running, the m.e.p. realized would be about 55 lb. With that m.e.p. the power developed per r.p.m. would be,

$$\frac{55 \times (14 \times 14 \times 0.7854) \times \frac{16}{12} \times 2}{33{,}000} = 0.684 \text{ hp., and to develop}$$

100 hp. would require 100 ÷ 0.684 = 146.19 r.pm.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Introducing the Index of Equipment



ON THE opposite page is an innovation in technical literature that will be a valuable aid to every man who has to do with power-plant equipment. It preserves for permanent record, in standardized form, a classified and illustrated history of progress in power-plant apparatus; a record that will gain in value in rapidly increasing measure as the weeks go by.

The superintendent and the chief engineer who look for the last word in power-plant apparatus will find in this an index of all the new machines and instruments available for obtaining economy—and find them instantly. There will be no need of going over back issues of *Power*.

The designer who must keep in touch with progress will find in this clipping index a complete summary of new developments.

Everyone interested in power-plant apparatus has in this index a centralized directory of "What is What" in new equipment for their requirements.

Patent lawyers will use this index as an indisputable evidence of priority, since the date of publication is printed on each item. Consulting engineers will welcome a perpetual record with such flexibility of filing.

Technical schools and colleges will appreciate the v of a continually up-to-date textbook on the important ject of power-plant equipment.

The method of utilizing this information is clearly cated in the illustration. Separate individual descript paste them on a 3 x 5 in. card, and file as desired. H for alphabetically filing can be taken from the P Buyers' Cyclopedia.

Power is glad of the opportunity of presenting this complishment to its readers.

The water power committee of the British Con Board of Scientific Societies has come to certain co sions, one of which is that the development of the Emp natural resources is inseparably connected with tha its water power, says the *Engineer*. It estimates tha Empire's water power is from fifty to seventy million h power. The Canadian branch of the committee showed Germany had utilized her water power most (43.4 per of the world's water power), Great Britain only more Russia, which has done least (8.3 per cent.) in this tion.

Condensed-Clipping Index of Equipment

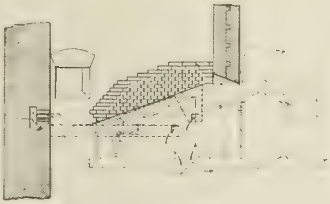
Clip, paste on 3 x 5-in. cards and file as desired

Furnace Construction, Bernitz.

Bernitz Method Co., Tremont, Tremont Bldg., Boston, Mass.

"Power," Dec. 17, 1918

Designed to prevent the formation of clinkers on boiler-furnace side walls and on bridge walls. System consists of an arrangement of firebrick in the furnace walls whereby air is admitted between the bricks of the side setting and at the bridge-wall into the fuel bed. Air is supplied by means of forced draft through suitable ducts and is controlled by a damper.

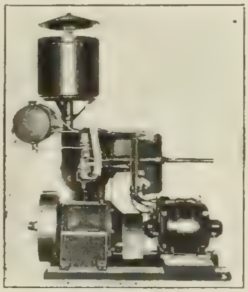


Plant, "Alco" Power and Lighting

Automatic Light Co., Inc., Minneapolis, Minn.

"Power," Jan. 21, 1919

Consists of a single-cylinder four-cycle water-cooled engine directly connected to a direct-current generator. Duplex wound. 110-volt power and lighting circuit; 7½-volt on starting and battery charging. Unit stops automatically when current is not being used.

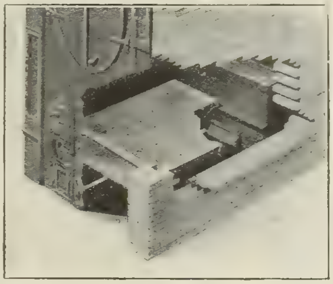


Furnace System, Carrick.

Carrick Engineering Co., 538 South Clark St., Chicago, Ill.

"Power," Dec. 24, 1918

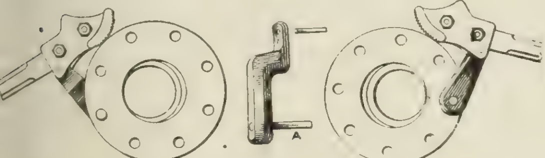
Grates are made with air passages oblique and nozzle-shaped, so that a multitude of separate streams of air travel through them to the fuel bed. Air is supplied through a duct leading to the ashpit, the supply being regulated by a damper.



Flange Attachment, Ideal

Kroeschell Bros. Co., 440 W. Erie St., Chicago, Ill.

"Power," Jan. 14, 1919



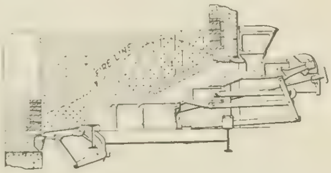
An attachment with chain wrench for use with flanges. Made in six sizes, with a total range of from 1½-in. to 20-in. in pipe sizes.

Furnace Blocks, Drake Non-Clinkering.

Sleicher & Drake, 5 Beekman St., New York City.

"Power," Feb. 4, 1919

A system whereby air is admitted to the boiler furnace along the fire line at the side walls and bridge-wall through tapered air holes in specially designed firebrick blocks. An air duct is formed at the back of the block and is run to a windbox. A damper controls the air supply to the air duct. The object is to prevent the formation of clinkers on the furnace setting.

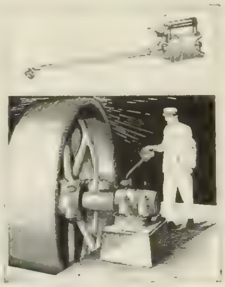


Oil Can, Bateman Illuminated

William G. Bateman, 154 Lackawanna Ave., East Stroudsburg, Penn.

"Power," Jan. 14, 1919.

Consists of a battery, electric light and wiring attachment. Pressing a lever closes the electric circuit and the light at the end of the oil-can spout illuminates the point to be lubricated. Light can be dispensed with when not needed by throwing back lever.

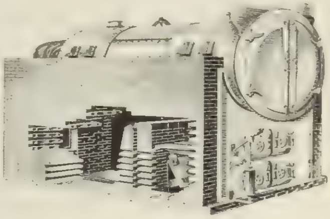


Smoke Preventer, Kosel.

Henry G. Kosel, 405 E. 168th St., New York City.

"Power," Jan. 21, 1919

Bridge-wall of furnace supplemented by a second one and so arranged that an air space is left between them. The opening at the top of the bridge-wall directs the air toward the combustion chamber and thus assists in the combustion of furnace gases. Air enters the bridge-wall air space from the ashpit. Air volume is controlled by a damper and a plunger in a cylinder containing glycerine or oil.

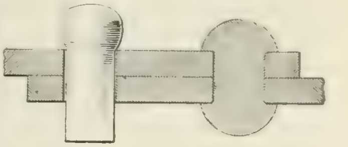


Rivet, American

American Flexible Bolt Co., Pittsburgh, Penn.

"Power," Dec. 31, 1918.

Rivet is designed with the head but partly formed. As the head is finished when driving, the metal is forced to flow into the opening between the shank and the plate, thus making a tight rivet. But one stock of each size is required as the head in driving can be formed to any desired shape.



Patented Aug. 20, 1918

Declining Supply of Motor Fuel

The Society of Automotive Engineers, at its recent annual meeting, devoted an entire session to discussion of the fuel question. This session was arranged at the suggestion of Dr. Joseph E. Pogue, of the Bureau of Oil Conservation, United States Fuel Administration, who presented a paper entitled "An Interpretation of the Fuel Problem." In this paper he pointed out how rapidly the demand for engine fuel has been increasing and will shortly exceed the available annual supply, although domestic production is about 340,000,000 bbl. and 60,000,000 bbl. are imported. He stated that about 20 per cent. of the crude petroleum is being converted into gasoline. This percentage can be increased by employing more modern refining methods, but not without increasing the price. The stock remaining will naturally become heavier all the time, and the yield of gasoline is thus bound to decline, so that finally not more than 2½ per cent. can be reclaimed as gasoline.

The blending of high-volatile gasoline made from natural gas with low-volatile refinery gasoline is widely employed, but the quantity made available by this method is relatively small. By lowering the volatility of the gasoline through the use of a larger percentage of the volatile petroleum such as kerosene, the supply of engine fuel can be increased, but not indefinitely or without disadvantages. The great objection to this plan is that existing types of automobile engines are not adapted for burning the heavier oil.

The hope of obtaining adequate supplies from Mexico he believed to be ill-founded because the extent of supply was an uncertain factor, and the ships of Great Britain and the United States are already drawing heavily on Mexican oil. Moreover, the heavy Mexican crude has low gasoline content. Substitute fuels, such as benzol, alcohol and shale-oil distillate may well be considered and may have to be adopted ultimately, but their price will necessarily be greater than that of gasoline today, because of high manufacturing cost. The retail price would reach 50 or 60c. per gallon.

The two possible (and perhaps temporary) solutions of the problem are: The more intensive refining (or "cracking") of the crude petroleum, with its necessarily greater cost per gallon and the development of engines capable of utilizing fuel less volatile than gasoline. A third item that will help to alleviate the situation is to build engines whose consumption is less than that of the average present-day engine, but not without adding machinery, expense and complications. Dr. Pogue sums up the situation as follows:

1. The automotive industry can no longer afford to ignore the engine-fuel problem.
2. The supply will positively decline, and the price will rise without our being prepared for it.
3. The burden falls upon the engine. It must adapt itself to less volatile fuel and should be made to burn oil with less waste.
4. To accomplish these results is the task put before the Automotive Engineers, who must study the petroleum, keep the industry informed and conduct researches with a view to averting an otherwise great calamity which would seriously disorganize an indispensable system of transportation.

Dr. David White, Chief Geologist of the United States Geological Survey, presented at this meeting an authoritative statement of American petroleum resources. His paper, entitled "The Unmined Supply of Petroleum in the United States," represents the result of elaborate investigations into the quantities of oil used and still available in the various producing districts of this country.

To satisfy public interest, the Government has had four estimates made of the oil resources of the United States. The latest of these places the oil available in the ground at the end of 1918 at 6,740,000,000 bbl. The total output of oil in the United States in 1917 was 335,315,601 bbl., and in 1918 probably 345,500,000 bbl. The total production from 1858 to date is estimated at 4,598,144,000 bbl. To supply our demand in 1918, 27,000,000 bbl. had to be taken from storage, and in addition, 31,000,000 bbl. was imported from Mexico. The deficiency in current production during 1918 was therefore 58,000,000 bbl. A continuation of the consumption curve indicates for 1919 a consumption beyond the 400 million mark (it was 397 million in 1918).

Dr. White fears that Mexico has less oil under ground than the United States. But he holds out the hope that processes may be developed which will permit of extracting oil on a commercial and economical scale from the great deposits of shale that exist in Colorado, Utah, Wyoming and Nevada. These deposits of oil shale three feet in thickness are capable of yielding 25 gal. of oil per ton of rock, or a total of 75 billion barrels. In this case the gasoline content would be about 12 per cent. Hydrocarbon engineers and chemists are expected to conduct the necessary researches leading to a utilization of the oil shales before the supply of petroleum from other sources declines too far. Immense distilling plants will be necessary to treat the millions of tons of shale rock, and to develop and construct these will require the expenditure of much time and capital.

Comparison of Steam Engines and Gas Engines

Late in 1918 a Congress of Civil Engineering was held at Paris, at which Mr. Compère, manager of the Parisian Association of Steam Boiler Proprietors, presented a paper dealing with the status of motive power in France at present. In it he observed that the operation of a gas producer demanded closer attention than did a steam engine. To this statement R. E. Mathot took exception, on the ground that it was unfair to compare the producer to the steam engine and that it should be properly compared to the steam boiler. In the latter case the producer had the advantage, as it needed to be fed with fuel every three hours and cleaned once a day, whereas a boiler needed frequent firing and cleaning of fires.

To the statement of Mr. Compère that the producer-gas engine worked faultily because of the varying proportions of steam and air admitted to the producer, Mr. Mathot replied that it was true enough as applied to obsolete designs, but that in modern plants the steam and air were automatically regulated. He admitted that keeping the fire-doors open too long might affect the power of the engine when working under full load, but he pointed out that in a steam boiler a drop of pressure would result from the same cause, and consequently a decrease of power of the steam engine, if it were overloaded. He emphasized the fact that the skill of the attendant affected the economy of the producer little, if at all, but that the economy of a steam boiler depended almost wholly on the stoker.

Mr. Compère quoted a statement to the effect that in a factory using uniform power ten hours a day, a gas engine would be advantageous up to 200 hp., but that with variable load conditions a good up-to-date steam plant would consume less fuel from 30 to 40 hp. up. Mr. Mathot objected to this statement and insisted that there was no example of a modern gas-power plant that consumed more than 1.5 to 1.7 lb. of anthracite per horsepower-hour, whereas a steam plant of even an improved design would use 3 to 4 lb. of coal of equivalent value. On the basis of a normal load of 200 hp. the comparison would be favorable to the gas producer because it could show an economy of 1 lb. of coal per brake horsepower-hour as against 2 lb. in the steam plant.

It was argued that a producer run during the day kept on consuming coal during the night, but Mr. Mathot contended that this was equally true of the steam boiler that is banked and that much more fuel would be required to hold the fire and raise steam in a steam boiler than in a producer. He stated that a 200-hp. boiler would require about 150 lb. of coal for banking and at least 200 lb. to come up to working pressure in the morning, whereas a 200-hp. producer would require only about 40 lb. of coal and the use of the blower for a quarter of an hour at starting.

United States Employment Service

For the first time in the history of America's develop-
nt, employers have an opportunity of selecting from a
ge and varied list of highly educated and experienced
n those individuals especially equipped to meet their
rticular requirements.

Engineers, executives, men of college training and prac-
al experience in business and technical fields are now
ng released from the Army, Navy and war work. The
ofessional and Special Section of the United States Em-
yment Service, a branch of the Department of Labor,
s been organized for the benefit of employers in need
these men. The service is entirely free of charge.

The organization already has thousands of well-educated,
perienced men on its lists and is daily placing many of
m in touch with employers. I. W. Litchfield, the head
the Professional and Special Section, was one of the
ganizers and directors of the United States Public Serv-
Reserve, which supplied high-grade engineers and busi-
s men to the Government for war work.

The Employment Service is now divided into two great
es for the purposes of the professional and special sec-
n. The New York office, headquarters for the Eastern
ne, at 16 East 42nd St., is in charge of the following
tes: Maine, New Hampshire, Vermont, Massachusetts,
ode Island, Connecticut, New York, New Jersey, Penn-
vania, Delaware, Ohio, Maryland, Virginia, West Vir-
ia, North Carolina, South Carolina, Georgia, Florida and
abama. The Chicago office, headquarters for the Cen-
l Zone, at 63 East Adams St., is in charge of all re-
ining states. Later zone offices will be established to
e charge of part of the territory now in the Chicago
ne.

The Service is now represented in each of the forty-eight states by a head office under the immediate jurisdiction of the Federal Director for that state. All local community labor boards are responsible directly to the Federal Director in their work of placing skilled and unskilled labor. The office of the Federal Director is particularly charged, however, in filling requisitions from employers for the highest type of business, professional and technical men. This class of men are registered only in the Professional and Special Section. In case the office of the Federal Director for a particular state cannot supply the high-grade man required by an employer, the requisition for that man is forwarded at once to the zone office to which that state is responsible. Likewise, the applications of men qualified for important positions are forwarded through the same channels.

The United Engineering Societies, composed of the four great engineering organizations—American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers and American Institute of Mining Engineers—are now coöperating with the Professional and Special Section in placing men in the engineering professions. The high standards maintained both by the Government organization and by the societies has proved to be of the utmost benefit to employers as well as to experienced engineers seeking employment.

The employer should at once get in touch with the office of the Federal Director in his state or write direct to either the New York or Chicago Zone offices. It is important that the employer give complete and specific details of the position to be filled, together with the maximum and minimum salary he is willing to pay. These details are regarded as confidential by the Government and are withheld from the applicant.

New Publications

EAM ENGINES. By E. M. Shealy, as-
sociate professor of steam engineer-
ing, University of Wisconsin. Pub-
lished by McGraw-Hill Book Co., 239
West 39th St., New York. 6 x 9 in.;
290 pages; 173 illustrations; cloth.
Price, $2.50.

his is used as a textbook for correspond-
e students in the University of Wis-
sin Extension Division and is an excel-
treatment of the subject for operating
ineers. The fundamental principles un-
ying the operation of the steam en-
e are presented in as simple and non-
hematical manner as possible. Enough
the practical features of steam-engine
gn, construction and operation are given
illustrate the principles and in such a
nner that operating engineers will be
e to supplement other applications of
principles presented. That part of the
k dealing with valve gears has been
le more complete than other sections,
to good purpose, because operating
ineers usually do not understand the
e-gear mechanism of their engines as
l as other parts. The work is divided
20 chapters under the titles: Principles
the Steam Engine; Corliss and Other
ines; Parts of the Steam Engine; Heat,
rk and Pressure; Properties of Steam;
icators; Indicated and Brake Horse-
er; Action of Steam in the Cylinder;
m-Engine Testing; The Slide Valve;
Valve Diagram; Valve Setting; Shift-
Eccentric and Meyer Valve; Reversing
hanisms; Corliss Valve Gears; Gov-
ing; Compound Engines; Condensing
aratus; Lubrication; and General Prin-
es of Steam Turbines.

FUEL FACTS

he United States Fuel Administration
issued a second revised edition of "Fuel
ts," which contains valuable informa-
for consumers and savers of fuel. A
y may be had by applying to the U. S.
Administration, Washington, D. C.

Personals

. V. Henderson, who until recently was
ociated with the firm of Pratt & Hen-
son, power-plant specialists, has been
ointed chief engineer of the Hotel Stat-
Detroit.

L. C. Vincent, for the last six years master mechanic at Wilson & Co.'s Oklahoma City plant, has taken a position as chief engineer of the Steffens-Brecht Creamery Co., of the same city.

Donald D. Davis, a man of practical engineering, accounting and factory executive experience, has been appointed to conduct an industrial department which has been established by the Liberty National Bank of New York for the purpose of offering its services in an advisory capacity on matters pertaining to manufacturing and industrial problems.

Engineering Affairs

The American Institute of Electrical Engineers will hold its seventh midwinter convention in the Engineering Societies Building, 33 West 39th St., New York City, Feb. 19-21.

The Detroit Engineering Society will hold a joint meeting with the Michigan Chapter of the American Society of Heating and Ventilating Engineers on Feb. 21. L. D. Royer, of the Power and Construction Department of the Ford Motor Co., will talk on "The Measurement of Flow of Liquids and Gases by Means of the Pitot Tube."

The American Electric Railway Association will hold its first midyear meeting and dinner since the entry of the United States into the war, in New York City on Mar. 14. The meeting will be held in the morning and afternoon in the Engineering Societies Building, 29 West 39th St., and the dinner in the evening in the grand ball room of the Waldorf-Astoria hotel.

Miscellaneous News

The New Jersey State Board of Boiler Rules met at Newark, N. J., Feb. 13 and adopted the recent revisions of Part I, Section I of the A. S. M. E. Boiler Code for construction of power boilers, which was reviewed, pages 196-198 of Feb. 11 issue of "Power," and the revision of Part I, Section II for construction of heating boilers, reviewed page 236 of this issue.

The Massachusetts Board of Boiler Rules, which held its semi-annual hearing on proposed changes on Nov. 7, 1918, has changed Rules 2 and 3, Part III, Sec. 1, so as to allow 0.035 per cent. instead of 0.03 per cent. of phosphorus (basic) in fire-box steel used in the construction of boilers. This now accords with the limit adopted by the American Society for Testing Materials and the Code of the American Society of Mechanical Engineers. The composition of extra-soft steel remains as before. This law becomes effective about July 1, but on application to the Board can be taken advantage of on receiving its permission. One boiler manufacturer has secured this permission in advance. A petition by a valve manufacturer that safety valves be allowed of the beveled-seat type only, was withdrawn without action by the Board.

Business Items

The August Mietz Corp. has moved from 424 East 19th St. to 310 East 19th St., New York City.

The Underfeed Stoker Co. of America has moved its general offices from the Harris Trust Building, Chicago, to the Book Building, Detroit. The Chicago quarters will be retained, however, as a district sales office.

The Joseph L. Sheldon Engineering Co. has moved into its new location at 238-242 Water St., Toledo, Ohio, where a thoroughly equipped machine shop has been fitted out and a full line of power plant machinery will be in stock. This company has recently taken over the entire output of the McNaull Boiler Co. of Toledo, and will shortly establish district representatives in all the principal cities.

Trade Catalogs

The Brown Hoisting Machinery Co., Cleveland, Ohio, has just issued its 96-page illustrated Catalog K for 1919, 8½ x 11 in. A complete book of information on "Brownhoist" locomotive cranes.

The Coppus Engineering and Equipment Co., Worcester, Mass., has issued a bulletin covering its Type CCC Coppus centrifugal turbo boiler-feed pump, and clearly describing its advantages. A copy may be had free upon request.

The Steere Engineering Co., of Detroit, Mich., has just issued its Bulletin No. 36 on "Plant Models." It illustrates the practical methods employed by this company in analyzing and determining plant requirements. A copy of the bulletin may be had free upon request.

New Construction

PROPOSED WORK

N. Y., Far Rockaway—The Far Rockaway Strand Theatre Co., Strand Theatre Bldg., New York City, plans to install a steam heating system in the 1 story 44 x [illegible] ft theatre which it plans to build on Central Ave. here. Total estimated cost, $100,000.

N. Y., New York—The Pictorial Review Co., 222 West 39th St., will install a steam heating system in the 12 story, 107 x 147 ft printing plant which it plans to build on 7th Ave and 39th St. Total estimated cost $1,000,000. Address H. Goodstein, Representative.

N. Y., New York—R. B. Smith, Consulting Engr., 50 East 42nd St., is in the market for 1 shape furnace and one plate furnace with 2 motor driven blowers, one hydraulic ram, 8 forge fires and one 1000-lb. steam hammer.

N. Y., Wards Island—The State Hospital Commission, Capitol, Albany, will receive bids until March 4th for the installation of a heating plant and sanitary electric work in the 3 story, 22 x 114 ft. building which it plans to construct at the State Hospital. Total estimated cost, $100,000.

N. J., Union Hill—The Board of Education plans to install a steam heating system in the 3 story, 100 x 190 ft. school building which it plans to construct on Hudson Ave. Total estimated cost, $250,000.

Penn., Allentown—The city plans to build an electric-light plant, to be operated in connection with the city water-works pumping station. H. T. Bascom, City Engr.

Penn., Harrisburg—The State Board of Health plans to build a new electric power plant at the Mount Alto Sanatorium.

Penn., Hawley—The Welewood Silk Mills plan to build a hydro-electric plant. W. F. Suydam, Mgr.

Md., Baltimore—The Building Committee of the Seventh Baptist Church, North Ave., and St. Paul St., plans to rebuild the church recently destroyed by fire. A steam heating plant and electric lighting system will be installed in same. Total estimated cost, $100,000. Address C. N. Friz, 14th floor, Lexington Bldg.

Md., Golden Hill—W. F. Applegarth will install a 75 h.p. steam boiler and a 25 h.p. engine in the 1 story, 80 x 175 ft. tomato canning factory which he plans to build. Total estimated cost, $5000.

Md., Hagerstown—The Board of Education of Washington Co. plans to build three 2 and 3 story school buildings, 1 at the north end of the city, addition to 1 on Antietam St. and 1 at Halfway. Steam heating plants will be installed in same. Total estimated cost, $200,000. A. K. Klinkhart, 27 West Washington St., Arch.

Fla., Pensacola—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install electric equipment at the Naval Air Station, here. Estimated cost, $30,000. Specification No. 3785.

Fla., Starke—The city plans to issue bonds for improvements to its power plant. Address the Mayor.

Miss., Hollandale—Bids will be received until April 8th by the Black Bayou D.D., Washington Co., (Greenville), for the construction of a 1 story pumping plant house and dam near here. Estimated cost, $17,000. Morgan Engineering Co., Goodwyn Institute Bldg., Memphis, Tenn., Engr.

Tenn., Memphis—The Board of County Commissioners plans to install a new electric-lighting plant in the local court house. Estimated cost, $10,000.

Ohio, Cleveland—The Board of Education, East 6th St. and Rockwell Ave., plans to install a steam heating and ventilating system in the 1 story school building which it plans to construct on East 146th St. near Kinsman Rd. Total estimated cost, $200,000. W. R. McCornack, East 6th St. and Rockwell Ave., Arch.

Mich., Detroit—The Monroe Sheet Metal & Roofing Co., 563 Myrtle St., will install a boiler, engine and generator in the factory which it plans to build on Pine and 5th St. Smith, Hinchman & Grylls, 710 Washington Arcade, Arch.

Mich., Detroit—The Water Board has submitted plans to the City Council for building and equipping a boiler house. Estimated cost, $439,600. G. H. Fenkell, Ch. Engr.

Mich., Detroit—The Board of Education plans to alter and improve the heating and ventilating systems in the Eastern High School building on Boulevard and Mack Ave. Estimated cost, $10,080.

Ill., Chicago—The Bankers Supply Co., 2251 South Park Ave., will install a steam heating plant in the 1 story, 100 x 370 ft. printing plant, which it plans to build on State St., near 59th St. Estimated cost, $120,000. R. E. Pingree, 209 South La Salle St., Arch.

Ill., Chicago—The Ohio Match Co., Wadsworth, Ohio, plans to install a steam heating system in the 8 story, 100 x 121 ft warehouse, which it plans to build here. Total estimated cost, $200,000. R. H. Hinsdale, 527 Erie Bldg., Cleveland, Ohio, Arch.

Wis., Eau Claire—The International Toy Co. will construct a separate transformer station in connection with the 60 x 300 ft plant which it plans to build. L. D. Pangborn, Mgr.

Wis., Milwaukee—The Milwaukee Paper Box Co., 400 Florida St., plans to install a steam heating system in the 5 story, 120 x 145 ft. paper box factory which it plans to build on South Pierce and Muskeg St. Total estimated cost, $225,000. Address Schnetzky & Son, Arch., 105 Wells St.

Wis., West Allis—The Common Council plans to build an electric light and power plant. J. Sweet, 521 Grand Ave., Milwaukee, Consultg. Engr.

Iowa, Sioux City—The Commissioners of Woodbury County are having plans prepared by W. Steele, Arch., 502 United Bank Bldg., for the construction of a 2 story, 60 x 180 ft. home on Bronson Rd., E. Plans include the construction of a separate building for heating, generating and water supply and equipment for same. Total estimated cost, $100,000.

Minn., Le Sueur—The city will receive bids until Feb. 21st for a 150 h.p., 150 lb. pressure tubular boiler, also a 200 h.p., 150 lb. pressure tubular boiler (only one boiler will be purchased).

Minn., Virginia—The city will install a steam heating plant, and mechanical ventilating system in the 3 story city hall and public auditorium which it plans to build. Total estimated cost, $200,000. A. E. Bickford, City Clk.

Kan., St. John—The city plans an election in April to vote on bond issue to build a new power house for the water and light departments.

Kan., Topeka—The State Legislature has approved the appropriation of $12,000 for stokers at the power plant and $10,000 for improvement to the water system, steam heating and electric plants for the Topeka State Hospital.

Neb., Omaha—The Overland Tire & Rubber Co., 917 Woodmen of the World Bldg., plans to build a power plant to develop 2500 h.p., in connection with the rubber and tire factory which it plans to construct on 36th St. and Belt Line Ry. Total estimated cost, $150,000.

Mo., Butler—J. F. Kern plans to build an electric light and power plant and is in the market for machinery for same.

Mo., Carrollton—The Water, Light & Transit Co. plans to improve its plant. Estimated cost, $3000. H. W. Graham, Mgr.

Mo., St. Louis—The Anheuser Busch Brewing Association, 9th and Pestalozzi St., plans to equip the second unit of its bevo plant, and is in the market for electric motors, elevators, power equipment and bottling machinery. H. Menzenwerth, Supt.

Tex., Aransas Pass—The France & Canada Oil Transport Co., 120 Broadway, New York City, N. Y., plans to establish an electric-light plant here.

Tex., Ft. Worth—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build a 1 story boiler and pump house transmission line and electric distribution system, in connection with the argon production plant which it plans to build at North Ft. Worth. Total estimated cost, $607,250.

Tex., San Antonio—Fire recently destroyed the plant of the San Antonio Public Service Co., Villita and South Presa St., entailing a loss of $25,000.

Okla., Woodward—The city plans an election in February to vote on a $30,000 bond issue which will be used to equip the water and light plant.

Colo., Breckenridge—The city plans to build an electric light plant.

N. M., Valedon—The Eighty Five Mining Co., Lordsburg, is in the market for a 1000 h.p. boiler, a 1000 h.p. steam turbine and steam eqiupment.

Ariz., Tempe—The city plans election soon to vote on bond issue for the construction of a gas and electric-light plant.

Ore., Astoria—The Commissioners of
Port of Astoria plan to sell $750,000 bo
for various improvements at the port
include enlarging power plants for the

Cal., Sacramento—R. Carstensen, 35th
and 5th Ave., has had plans drawn for
construction of a cold storage and
manufacturing plant on R St., between 16
and 17th St. Estimated cost, $225,000

Que., Montreal—The Department of Pu
lic Works, Ottawa, Ont., plans to appr
priate $1,000,000 for the construction of
cold storage plant here.

Que., Montreal—The Stinson-Reeb Bu
ers Supply Co., 45 St. Alexander St., is
the market for a portable locomotive
upright type boiler, 25 to 35 h.p.

Que., Quebec—C. J. Rockwell, 7
Erables Ave., recently purchased the R
tray Block from the "La Compagnie d'A
garage de Quebec, plans to build a fi
class cold storage plant.

Ont., Owen Sound—W. Kennedy & So
Ltd., is in the market for a 15-ton elect
traveling crane, 39 ft. 10 in. span, 3 mo
60 cycle, 550 volt, to be installed in p
recently erected.

Ont., Toronto—A. W. Adams, 55 W
Lodge Ave., is in the market for a 500-h
engine.

CONTRACTS AWARDED

R. I., Providence—The Revere Rub
Co., 355 Valley St., has awarded the co
tract for the construction of a 1 story,
x 90 ft. boiler house on Hemlock St.,
the Cruise & Smiley Construction Co.,
East Ave., Pawtucket. Estimated c
$30,000.

N. Y., Wards Island—The Bureau
Yards & Docks, Navy Department, Was
ington, D. C., received bids for install
refrigerating plant equipment at the Na
Hospital Reservation here, from the Vil
Manufacturing Co., 872 Clinton St., M
waukee, Wis., $20,935, (90 days); Fri
Manufacturing Co., West Main St., Wayn
boro, Penn., $21,074 (93 days); Mayer
Machine & Engineering Co., 315 Grant Av
Jersey City, N. J., $21,192 (60 days).

Penn., Philadelphia—The Bureau
Yards & Docks, Navy Department, Wa
ington, D. C., has awarded the contract
the construction of a water power pu
and tank house, at Grays Ferry Rd., to
H. McCloskey, Jr., 1620 Thompson St
$15,567 (90 days).

Md., Baltimore—The War Departme
Washington, D. C., has awarded the c
tract for installing heating plants in 5 a
ditional buildings at General Hospital
7, here, to the Enterprise Steam & H
Water Heating Co., 600 North Howard S
electric work to the Brueckmann Elect
Co., 501 Keyser Bldg.

D. C., Anacostia—The Bureau of Yar
& Docks, Navy Department, Washingt
D. C., has awarded the contract for
stalling a heating system in the hangar
the Naval Air Station, to L. E. Breuning
Colorado Bldg., Washington, at $10,625 (
days). Noted Feb. 11.

Va., Hampton Roads—The Bureau
Yards & Docks, Navy Department, Wa
ington, D. C., received bids for installi
mechanical equipment and piping for t
central power plant at the Naval Operati
Base, (a) net price and time for the w
complete in accordance with the drawin
and specification, (b) net production
price and time from (a) for furnishing b
not installing the feed water heater, st
age tank, pumps and certain steam
haust, boiler feed and drip piping in conne
tion with the above equipment to the poi
indicated on the drawings, from H.
Friedstedt, 327 South La Salle St., Chica
Ill., (a) $4898 (50 days), (b) $14; R
Engineering Co., Farmers Bank Bl
Pittsburgh, Penn., (a) $6840 (30 da
(b) $19.

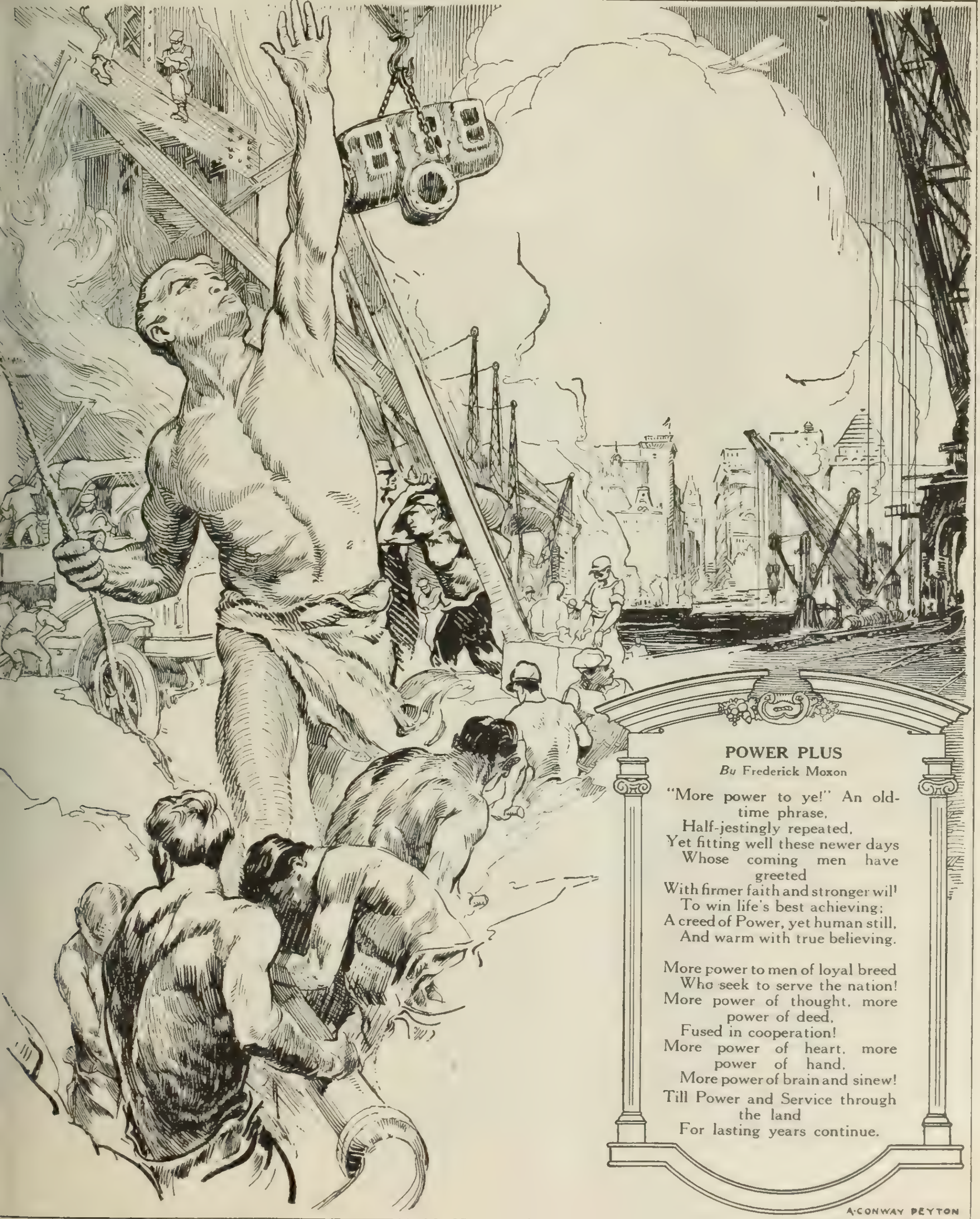
Minn., Bemidji—The city has award
the contract for installing pumping syste
and building 2 reservoirs, having a
pacity of 200,000 gallons, to Layne & Bo
ler, Chelsea Ave., Memphis, Tenn. Es
mated cost, $35,000.

Cal., Los Angeles—The Board of Pu
lic Service, 645 South Olive St., has awar
ed the contract for furnishing sheet ste
rivets and pipe section for pipe line a
penstocks for power plant No. 2 in S
Francisquito Canyon, to the Western Pi
& Steel Co., 1758 North Broadway. Est
mated cost, $92,000. Noted Jan. 7.

Cal., San Diego—The San Diego
Arizona Ry. has awarded the contract f
the construction of railway shops, inclu
ing a boiler room, oil room, etc., to Bra
ner & Hunter, 1444 I St. Estimated co
$19,527.

POWER

Volume 49 New York, February 25, 1919 Number 8



POWER PLUS

By Frederick Moxon

"More power to ye!" An old-time phrase,
Half-jestingly repeated,
Yet fitting well these newer days
Whose coming men have greeted
With firmer faith and stronger will
To win life's best achieving;
A creed of Power, yet human still,
And warm with true believing.

More power to men of loyal breed
Who seek to serve the nation!
More power of thought, more power of deed,
Fused in cooperation!
More power of heart, more power of hand,
More power of brain and sinew!
Till Power and Service through the land
For lasting years continue.

Placing Valves in Unsafe Positions

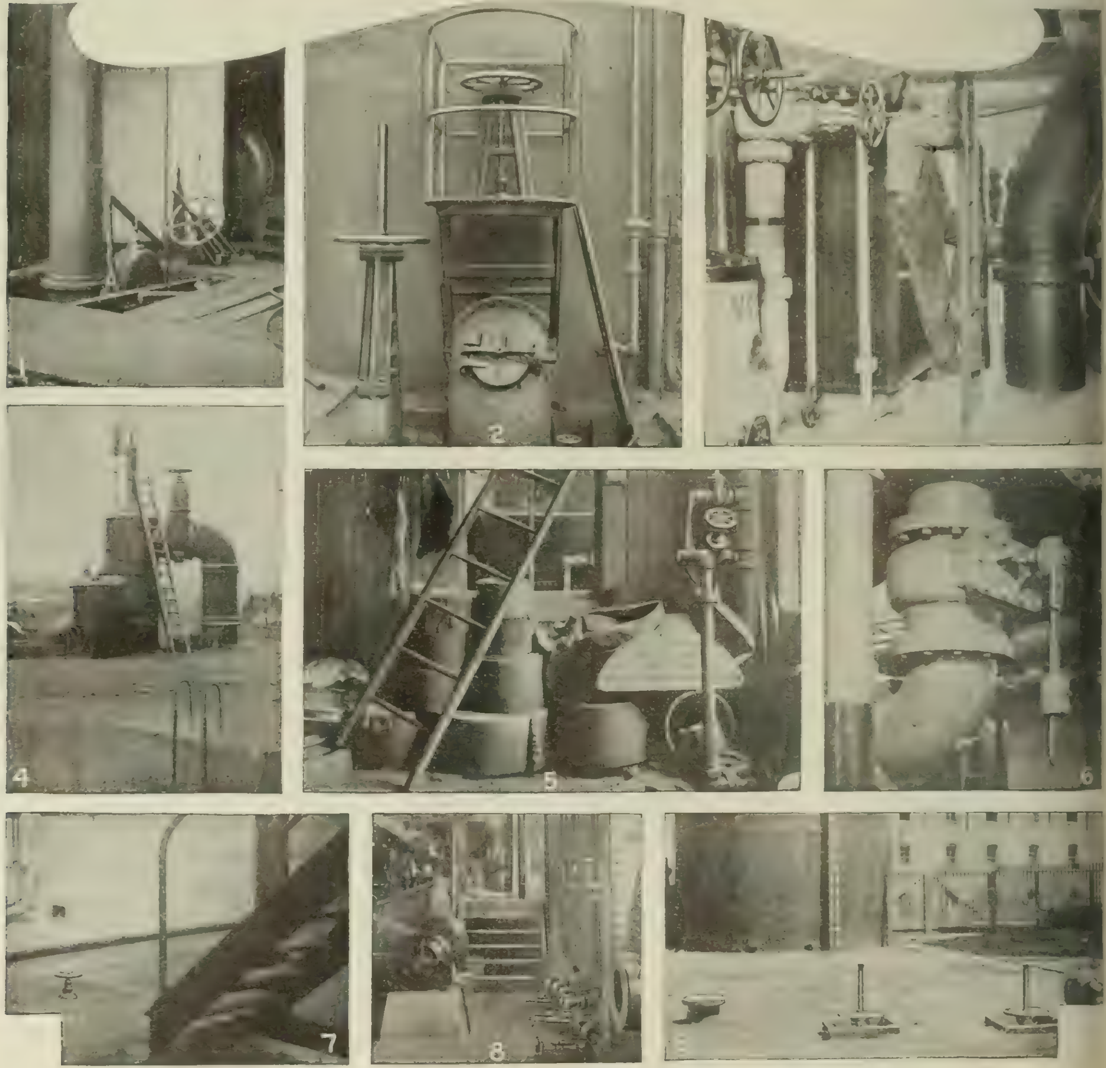
By V. R. Hughes

Valves are not always installed in the most convenient location to be quickly reached, and sometimes when they are convenientily located they constitute a tripping or bumping hazard. A number of such installations are illustrated.

VALVES that have to be operated frequently or quickly should be accessible, so that they can be reached safely even though the room in which they are located may be filled with smoke or steam. Often the timely opening or closing of a valve will save lives or prevent a shutdown of the station. Valves are generally conveniently located when installed, but as time goes on obstructions such as loose material, boxes and sometimes hot objects or moving machines are placed so that they cannot be quickly and safely reached.

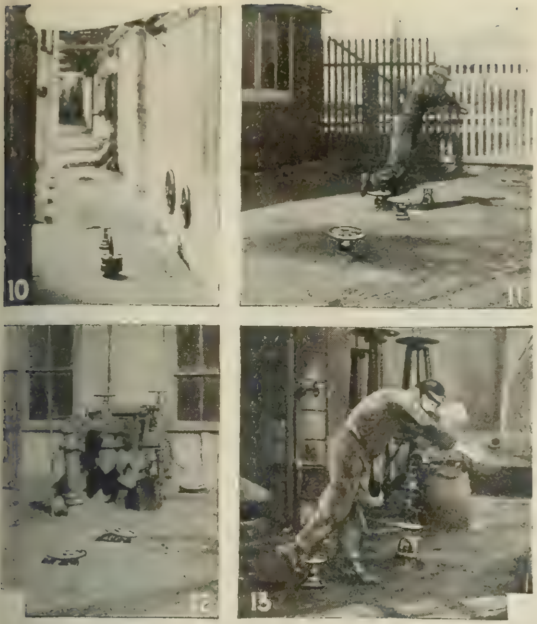
Stop and blowoff valves should be protected so that they cannot inadvertently be opened on a boiler that is down for cleaning, repairs or inspection.

There have been many serious scalds from opening steam header, feed-water and blowoff valves, admitting steam or hot water into a boiler in which there was a workman or an inspector. This is more especially so with blowoff valves where there is a common blowoff pipe or blowdown tank. Often the boiler washer will open the blowoff valve so connected to drain the boiler,



FIGS. 1 TO 9. ILLUSTRATIONS OF HAZARDOUS VALVE INSTALLATIONS

Fig. 1—Valve wheel over pit. Fig. 2—Safety platform. Fig. 3—Protruding valve stem. Fig. 4—Ladder necessary to reach valve. Fig. 5—Hose and valve obstructed. Fig. 6—Weight a danger. Fig. 7—Valve stem at stair approach. Fig. 8—Valve stems obstruct passageway. Fig. 9—A tripping menace.



FIGS. 10 TO 13. VALVE STEMS PROTRUDING ABOVE THE FLOOR AND GROUND LEVEL A SOURCE OF ACCIDENTS

forgetting to close it again before getting back into the boiler, there being no pressure on the line at the time to remind him. Later, if one of the other boilers is blown down into the common blowoff line, hot water is blown into the dead boiler, scalding the man inside. Such valves should always be locked by the foreman or removed and the pipe blanked off with a blind gasket.

Boiler stop valves should have a continuous runway leading to each boiler valve. The runway should be rail-guarded on both sides so that an attendant can follow the hand-railing to each boiler discharge valve in the dark or with the room full of steam.

The pop safety valve should never discharge across a runway or toward the stop valves. The safest way is to have a vertical discharge pipe with a drip hole at the bottom on each valve. Workmen going upon the roof trusses over safety valves so equipped should be warned about the danger of the valve operating and blowing steam over them.

Again, a good valve may be conveniently installed, but in time the handwheels become detached or broken, causing the valve to become inoperative unless special tools are at hand. Frequently, the handwheels are removed with the idea that the valve will not be changed from its open or closed position, but there is no assurance of this as a pipe or monkey wrench will usually suffice to operate the valve and injury or damage may result from its being opened or closed unknown to the proper authority. The handwheel should be left on the valve with a danger sign attached, stating that the valve is not to be operated, or the wheel should be locked with a padlock and chain. In some plants round split sheet-metal covers are placed over the handwheels, and when these are locked the wheels cannot be turned without removing or destroying the covers.

Some of the conditions enumerated in the foregoing are shown in the accompanying illustrations.

In one instance the throttle valve on a turbine-driven boiler-feed pump is located so high that it is necessary for the operator to stand on the suction pipe of the pump and bearing of the turbine to open or close the valve. Fig. 1 shows a valve with the handwheel at the edge of an open pit. When operating the valve there is danger of the operator falling into the pit.

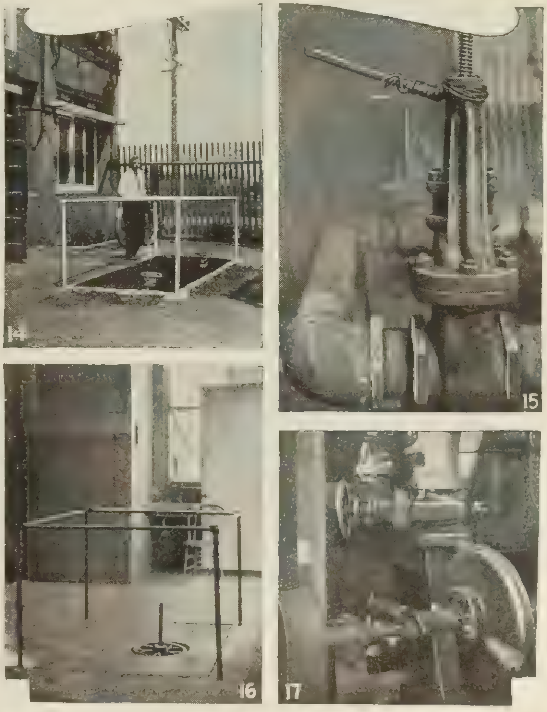
Frequently, large gate valves are so placed that it is necessary for the operator to stand on a ladder to operate them. Such an installation is shown in Fig. 4. That there is danger of the operator falling from the ladder is evident. As a contrast, Fig. 2 shows a large gate valve provided with a substantial platform and guard rail to protect the workmen from falling.

Carelessness of workmen frequently makes safety apparatus practically useless, as is shown in Fig. 5. Although the hose valve is conveniently located, it and the hose are obstructed with loose and junky material.

In Fig. 3 is shown a gate valve on a hotwell discharge line so located that when the valve is open an operator climbing the iron ladder to the condenser platform is in danger of having his back injured by the prejecting valve stem.

In Fig. 6 is shown an exhaust relief valve alongside a narrow passageway. When the relief valve is closed the lever is horizontal, but should the valve open the lever drops to a vertical position. There is danger of the weight working loose from the end of the lever and falling and injuring someone.

Fig. 7 shows a valve bonnet and valve wheel projecting above a pipe-trench cover at the foot of a stairway. This constitutes a serious tripping hazard.



FIGS. 14 TO 17. GOOD AND BAD EXAMPLES OF VALVE INSTALLATION

Fig. 14—Valve stems protected by railings. Fig. 15—A poor makeshift. Fig. 16—Valve pit guarded by railing. Fig. 17—Valve placed at inconvenient angle.

Oil pressure line valves with stems and wheels projecting into a commonly used passageway constitute a serious tripping hazard, as is shown in Fig. 8.

In Fig. 10 valve stems and stuffing-box are shown projecting through iron pipe-trench covers along a commonly used passageway.

Figs. 9, 11, 12 and 13 show underground pipe valve wheels and stems projecting above the ground in passageways, constituting a tripping hazard.

Fig. 14 shows the valve stems and wheels as in Fig. 11, protected by a pipe-guard railing.

Fig. 16 shows a large gate valve and pit guarded by a pipe railing. The opening in the pit cover should be larger so that the operator would not be in danger of injuring his hands when operating the wheel.

Fig. 15 shows a gate valve with the arms and rim of the handwheel broken off. A makeshift handle has been substituted, which makes the operation of the valve uncertain and the whole slovenly.

The final view, Fig. 17, shows the gate valve on a centrifugal-pump discharge installed with the handwheel in close quarters, compelling the operator to lean over the pump and possibly the revolving shaft. The valve could just as well have been swung around about two bolt holes, thus making it convenient to reach from the front of the pump.

Hytempite Furnace Cement

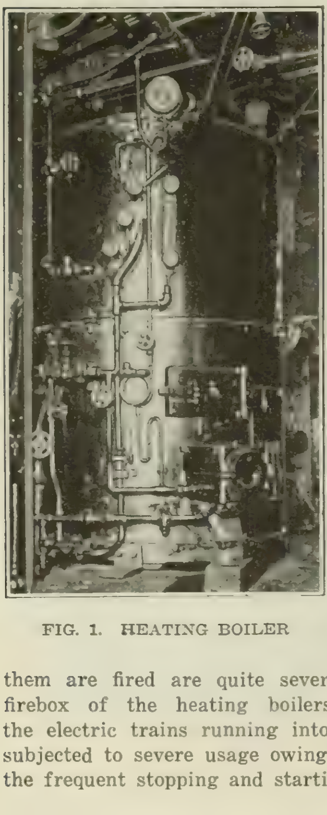


FIG. 1. HEATING BOILER

Ordinary fireclay will soon burn out and crumble when used as a binder for furnace firebrick, thus necessitating frequent repairs in order to keep the furnace in proper condition. A number of prepared furnace cements are on the market for use as binding material for the brickwork, one of which, known as Hytempite, is manufactured by the Quigley Furnace Specialty Co., Inc., 26 Cortlandt St., New York City. This cement possesses such qualities as to enable it to expand and contract to the varying temperatures without losing its bond on the furnace brickwork. Furnace conditions vary according to the type of boiler plant, and the operating conditions under which some of them are fired are quite severe. For instance, the firebox of the heating boilers (Fig. 1) used on the electric trains running into New York City are subjected to severe usage owing to the jar caused by the frequent stopping and starting, as well as that of the train movement. As a result the joints of the brickwork in the heating-boiler furnace deteriorate after a week or ten days, when repairs are necessary, thus showing that fireclay is not a suitable binder for this kind of furnace. The condition of the furnace after about ten days' run is shown in Fig. 3.

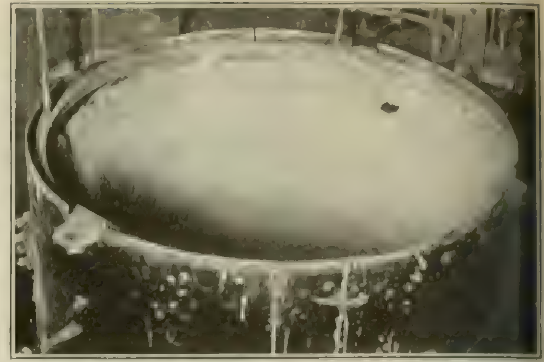


FIG. 2. BRICK LINING SET WITH HYTEMPITE

To overcome this trouble the New York, New Haven & Hartford R.R. has recently used Hytempite as a bond for the firebrick on the boiler furnaces in one of its electric locomotives. Fig. 2 shows its application. It is not known how long this furnace lining will stand up, as this is the first boiler that has been treated, but after being in service for about seven weeks it was still in good condition. This, compared with ten days' service, speaks well for the merits of the binding cement and the indications are that much better results will be obtained with the boiler furnace lining laid up in this manner.

This cement is suitable for use in laying up boiler furnaces in power plants as well as furnaces used for other purposes where the heat is intense.

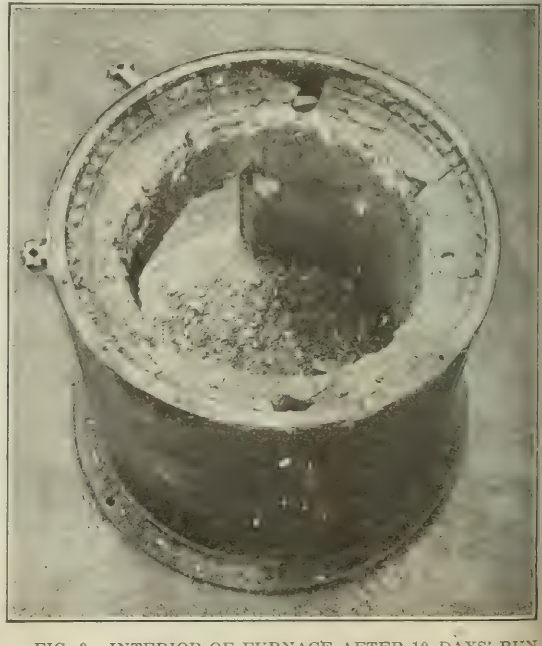


FIG. 3. INTERIOR OF FURNACE AFTER 10 DAYS' RUN

How Much Should a Flywheel Weigh?

By RUFUS T. STROHM

The weight of a flywheel depends on the allowable variation in rotative speed and the diameter of the wheel. It may be calculated approximately by the method explained in the article, using simple rules and ordinary arithmetic.

ORDINARILY, the operating engineer is not concerned about the weight of the flywheel on any of his engines, because that is a matter which fixed by the designer and builder; nevertheless, he ay be curious to know what factors control the size id weight of a flywheel, and how these points are dermined before the engine is built. To do so, he must st have some idea as to what a flywheel does.

The purpose of a flywheel on an engine is to produce desired degree of steadiness in the speed of rotation the crankshaft. Of course, the governor is used for e same purpose; but there is a great difference beeen the fields of action of the two. The governor adsts either the steam pressure or the cutoff according the load on the engine, and so maintains a praccally uniform number of revolutions per minute over ng periods. The flywheel, on the other hand, prevents y undesirable change of speed within the limits of a ngle revolution.

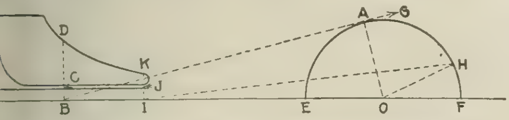


FIG. 1. VARIATION OF PRESSURE ON CRANKPIN DURING STROKE

The factors that tend to produce a variation of rotave speed within a revolution of the crankshaft are ree: The changing pressure of the steam in the cylinr, the changing relative positions of connecting-rod id crank, and the changing force required to set the reprocating parts in motion during the early part of the roke and bring them to rest during the later part the stroke.

The effect of the first two of these factors may read- be understood by referring to Fig. 1, which shows ordinary indicator diagram and two different posins of connecting-rod and crank. When the crank is *OA*, the crosshead is at *B*, and the forward pressure r square inch of piston area is represented by *CD*. s the connecting-rod and the crank are almost at right gles at *A*, practically the entire thrust of the rod is ailable for turning the crank; for it must be remembered that the force which turns the crank is that nich acts at right angles to *OA*, or tangent to the ankpin circle *EAF*, as indicated by the arrow *G*.

When the crank is at *OH*, the crosshead is at *I*, and e forward pressure per square inch of piston area is presented by *JK*. This is much shorter than *CD*, owing that the force exerted on the crankpin is conderably smaller near the end of the stroke than near the beginning. Furthermore, the relative positions of the crank *OH* and the connecting-rod *HI* are such that most of the thrust of the connecting-rod merely produces pressure on the crankpin and the crankshaft bearings, and has little effect in turning the crank *OH*. As a consequence, there is a wide variation in the turning force on the crank throughout the stroke; and as this force determines the amount of work being done during any interval, it follows that the work expended in rotating the crankshaft varies according to the position of the crosshead.

Now, during a short interval, as, for example, a single stroke of the engine, the load may be considered constant. The load then constitutes a uniform resistance which must be overcome by the turning force acting at the crankpin. But, as this turning force is variable, the work done at the crankpin is alternately greater and less than the uniform load under which the stroke is made. It is for the purpose of overcoming this inequality that the flywheel is used. The flywheel absorbs and stores up in itself the excess of work done while the turning force is greater than the resistance; and when the turning force becomes less than the resistance, toward the end of the stroke, the flywheel gives back to the crankshaft the work that it stored up during the early part of the stroke.

EFFECT OF WEIGHT OF RECIPROCATING PARTS

The third factor tending to cause variation in the turning force is the effect of the reciprocating parts. At the beginning of the stroke these parts are at rest; near the middle of the stroke they are moving at the same speed as the crankpin; and at the end of the stroke they are again at rest. To bring these parts up to speed, force must be applied; and when they have been set in motion, force must be applied to bring them to rest again. During the early part of the stroke, therefore, a part of the work of the steam on the piston is used in speeding up the reciprocating parts, and so the force acting on the crankpin is correspondingly reduced; but during the later part of the stroke, while these parts are being brought to rest, they give up the work stored in them and so add to the force exerted on the crankpin. The heavier the reciprocating parts and the greater their speed, the greater is the amount of work they alternately take up and give back.

To find the weight of flywheel required for an engine, it is necessary to start with the indicator diagrams. If the engine has not been built, the theoretical diagrams may be constructed according to the known data. If the engine has already been built, and the weight of the flywheel is to be checked, diagrams may be taken in the usual way.

To illustrate the method to be followed, let it be required to find the weight of flywheel for an 18 x 24-in. double-acting engine cutting off at one-fifth stroke, with a clearance of 6 per cent., an initial pressure of 120 lb., absolute, a compression pressure of 60 lb., absolute, a back pressure of 18 lb., absolute, a connecting-rod four times as long as the crank, and a rotative speed of 250 r.p.m. Assume further that the total weight of the reciprocating parts is 500 lb., which includes piston, piston rod, crosshead, and from half to two-thirds of the weight of the connecting-rod.

The theoretical diagrams constructed according to the foregoing data are shown in Fig. 2. At any instant the net steam pressure per square inch, urging the piston forward, is the difference of pressures on opposite sides. For example, at the position *A* the net pressure per square inch is represented by *BC*. But at the position *D* the net pressure is *EF*, which is negative; that is, the pressure opposing forward movement is greater than that tending to produce forward movement. If, therefore, the forward-pressure line of one diagram is combined with the back-pressure line of the other diagram, the result will be a diagram of net pressures urging the piston forward. This combined diagram is indicated by the heavy outline in Fig. 2. If the ordinates of the combined diagram are laid off from a straight base line, the diagram in Fig. 3 will result, the part lying below the line *AB* representing the back pressures that are in excess of the forward pressures. At the point *C*, where the curve crosses *AB*, the steam pressures on opposite sides of the piston are equal and the net pressure is zero.

The ordinates of the diagram in Fig. 3 do not, however, represent correctly the pressures that produce the turning of the crank, because some force is required to speed up the reciprocating parts, and also because the reciprocating parts in slowing down at the end of the stroke increase the effective force that acts on the crankpin. The force required to change the speed of the reciprocating parts, called the inertia force, may be calculated for various positions of the piston and then subtracted from or added to the net forward pressure at that point, thus giving the actual pressure transmitted to the connecting-rod. The inertia force may be found as follows:

Rule: Multiply together 0.000018 times the weight of the reciprocating parts in pounds, the stroke in inches, the square of the number of revolutions per minute, and the inertia-force factor taken from Table I, and divide the product by the square of the diameter of the piston in inches. The quotient will be the inertia force per square inch of piston area.

The speed of the reciprocating parts changes continuously throughout the stroke, and the inertia force therefore has different values at different points in the stroke. Table I gives the values of the factors to be used in the foregoing rule, to find the inertia force at equal intervals of 0.10 stroke in the movement of the piston, starting from the head end. The minus sign in front of a factor indicates that the inertia force opposes the forward movement of the piston, and the plus sign that it assists the forward pressure on the piston.

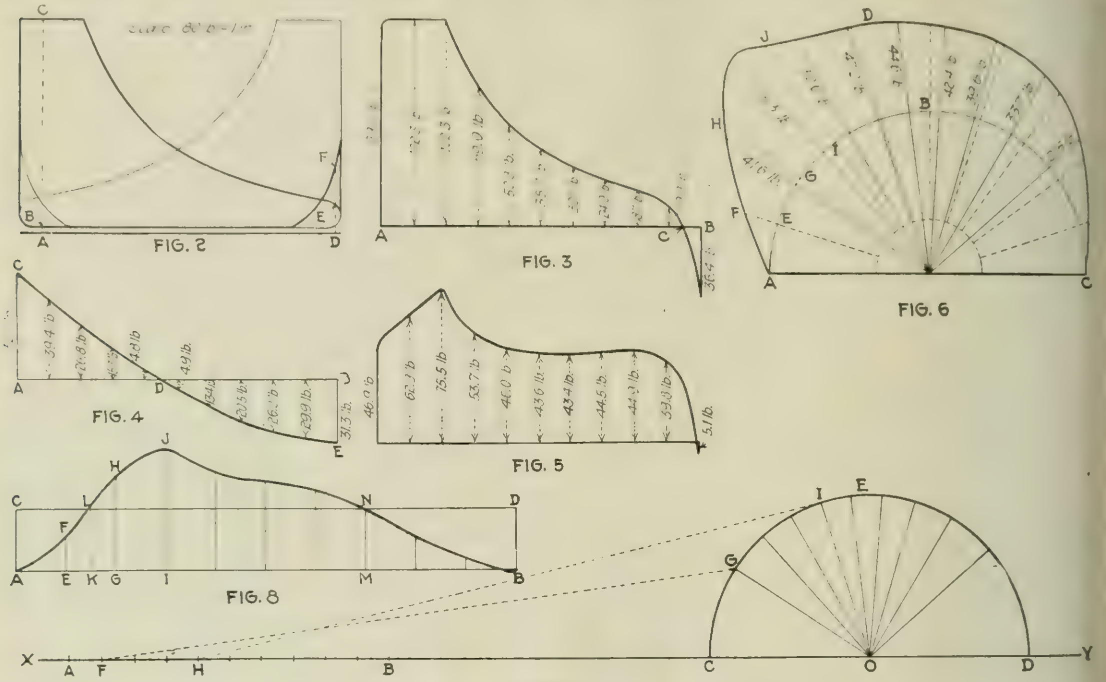


FIG. 2
FIG. 3
FIG. 6
FIG. 4
FIG. 5
FIG. 8
FIG. 7

FIGS. 2 TO 8. DIAGRAMS FOR FINDING ENERGY ABSORBED AND GIVEN UP BY FLYWHEEL DURING ONE STROKE

By the aid of the rule just given, it is a simple matter to find the value of the inertia force at intervals of one-tenth of the stroke. Take, for example, the zero position, with the piston at the head end of the cylinder. At this position the inertia-force factor has a value of 1.25, according to Table I. The other values to be used are given in the data assumed for the engine. Then, the inertia force per square inch of piston at the beginning of the forward stroke is

$$\frac{0.000018 \times 500 \times 24 \times 250^2 \times 1.25}{18^2} = 52.1 \textit{ lb.}$$

That is, a pressure of 52.1 lb. per square inch of piston area is required to set the reciprocating parts in motion rom the head-end dead-center. By a similar calculation he inertia force at each one-tenth of the stroke may be ound. After the inertia forces for all points in the troke are calculated, they should be laid off in the form f a diagram, as in Fig. 4. A straight line AB equal to he length of the indicator diagram is drawn and divided nto ten equal parts. At these points ordinates are rected and the calculated values of the inertia forces re laid off to the same scale as that used in the indiator diagram, or 80 lb. to the inch. Thus, the distance C, which represents 52.1 lb., must have a length of $2.1 \div 80 = 0.65$ in.; and similarly with the other engths. The values calculated by the use of an inertia-orce factor with a minus sign are laid off above the line B and those found by using a factor with a plus sign re laid off below AB. The smooth curve CDE drawn hrough the ends of these ordinates crosses the line AB t D, indicating that at this point the reciprocating parts re moving at their greatest speed and therefore are either opposing nor aiding the pressure on the piston.

The next step is to find the actual pressures per square ich of piston area effective in producing rotation of the rankshaft. The diagram in Fig. 3 shows the net forard pressures, and Fig. 4 shows the inertia forces that ppose or assist the net forward pressures; therefore, the pressures marked on the ordinates above the base ne in Fig. 4 are subtracted from the corresponding ressures in Fig. 3, the remainders will represent the ressures available for producing rotation of the crank, p to the point where the inertia force becomes zero. eyond this point the pressures on the ordinates below e base line in Fig. 4 must be added to the correspondg pressures on the diagram in Fig. 3, to find the presres available for rotating the crank during the reainder of the stroke.

TABLE I. INERTIA-FORCE FACTORS FOR VARIOUS PISTON POSITIONS

art of rward troke	Ratio of Connecting-Rod to Crank				
	4	4.5	5	5.5	6
0.00	—1.250	—1.222	—1.200	—1.182	—1.167
0.10	—0.945	—0.921	—0.907	—0.896	—0.887
0.20	—0.644	—0.636	—0.630	—0.629	—0.622
0.30	—0.368	—0.369	—0.369	—0.370	—0.371
0.40	—0.114	—0.121	—0.127	—0.132	—0.136
0.50	+0.117	+0.106	+0.096	+0.088	+0.081
0.60	+0.321	+0.307	+0.296	+0.287	+0.279
0.70	+0.493	+0.480	+0.471	+0.463	+0.457
0.80	+0.628	+0.621	+0.615	+0.613	+0.610
0.90	+0.717	+0.723	+0.728	+0.733	+0.737
1.00	+0.750	+0.778	+0.800	+0.818	+0.833

ABLE II. TANGENTIAL-PRESSURE FACTORS FOR VARIOUS PISTON POSITIONS

art of rward roke	Ratio of Connecting-Rod to Crank				
	4	4.5	5	5.5	6
0.00	0.000	0.000	0.000	0.000	0.000
0.10	0.662	0.655	0.649	0.644	0.641
0.20	0.868	0.861	0.854	0.849	0.844
0.30	0.979	0.970	0.964	0.959	0.955
0.40	1.026	1.019	1.013	1.009	1.005
0.50	1.024	1.019	1.015	1.013	1.011
0.60	0.978	0.976	0.975	0.974	0.973
0.70	0.889	0.890	0.891	0.893	0.894
0.80	0.751	0.755	0.759	0.762	0.765
0.90	0.542	0.549	0.554	0.558	0.561
1.00	0.000	0.000	0.000	0.000	0.000

Fig. 5 is the effective-pressure diagram obtained by mbining the pressures in Figs. 3 and 4 in the manner st explained. At the beginning of the stroke, the fective pressure is $99.0 - 52.1 = 46.9$ lb., the pressures 99.0 lb. and 52.1 lb. being taken from Figs. 3 and 4 spectively, at corresponding piston positions. At the d of the stroke, the pressure in Fig. 3 is negative and as a value of 36.4 lb.; consequently, when the pressure 31.3 lb is added to it, the sum is $- 36.4 + 31.3 =$ 5.1 lb. Therefore the value of 5.1 lb. is laid off below the base line in Fig. 5, to represent a negative pressure.

The pressures shown by the diagram, Fig. 5, are not applied at the crankpin in a direction at right angles to the crank; and as the force acting tangent to the crankpin circle is that which actually causes the crank to turn, the tangential pressures at the crankpin for the several positions of the crank must be calculated. This is done by multiplying the pressures shown on the diagram, Fig. 5, by factors taken from Table II, corresponding to the positions of the piston in the stroke.

Calculation of the Tangential Pressure

At the beginning of the stroke, the effective pressure is 46.9 lb. per square inch of piston, as shown in Fig. 5; but the piston rod, connecting-rod and crank are in the same straight line, and so this pressure is exerted wholly as a thrust on the crankshaft bearing, none of it acting to turn the crank. Therefore, the factor in Table II for the zero position is zero. If 46.9 is multiplied by zero, the product is zero; that is, there is no tangential pressure at the beginning of the stroke. The same thing is true at the end of the stroke. At one-tenth stroke, the effective pressure is 62.9 lb. and the factor from Table II is 0.662; consequently, the tangential pressure is $0.662 \times 62.9 = 41.6$ lb. per square inch of piston area. In a similar manner, the tangential pressure at each of the remaining piston positions may be found.

If the tangential pressures for the several piston positions are laid off on the corresponding positions of the crank, a tangential-pressure diagram will result, such as that shown in Fig. 6. The semicircle ABC is drawn with a diameter AC equal to the length of the indicator diagram in Fig. 2 and the tangential pressures are laid off outward from the semicircle on the full lines representing the crank positions, to the same scale of pressures as in the preceding diagrams. The curve ADC is then the tangential-pressure curve.

The crank positions corresponding to the positions of the piston are easily found by the method shown in Fig. 7. On a straight line XY the distance AB is laid off to equal the length of the diagram in Fig. 2, and AC is made equal to twice AB, to represent the length of the connecting-rod, which is twice the stroke, or four times the length of the crank. Then CD is made equal to AB and the semicircle CED is drawn. The stroke AB is divided into ten equal parts to show the piston positions.

Finding Crank Position from Piston Positio

When the piston is at F it has moved one-tenth of the stroke from A and the crank is at OG. The point G is found by setting a pair of compasses to the length AC of the connecting-rod, placing the point of the compasses at F and drawing an arc to cut the semicircle CED, which it will do at G. Similarly, when the piston is at H, the crank is at OI, the point I being found by using H as a center and a radius equal to AC, and drawing an arc to cut the semicircle. The other crank positions are found in like manner. When they have been found, they are transferred to the semicircle on Fig. 6 and the tangential pressures are laid off, as already explained.

The final step in the drawing of diagrams is to draw the tangential-pressure diagram to a straight base, as shown in Fig. 8. This means simply that the diagram in Fig. 6 is straightened out. First, the semicircle ABC

in Fig. 6 is divided into a number of equal parts, say ten, and through these points crank positions are drawn as shown by dotted lines. In Fig. 8 the line *AB* is made equal in length to the semicircle *ABC* in Fig. 6 and is also divided into ten equal parts. Vertical lines are drawn at the points of division, and on them are laid off the ordinates of the tangential-pressure diagram in Fig. 6, measured along the dotted lines. Thus, in Fig. 8, the heights *EF*, *GH*, *IJ*, etc., are laid off exactly equal to the heights *EF*, *GH*, *IJ*, etc., in Fig. 6 and the smooth curve *AFHJB* is drawn.

WORK DONE ON CRANK IN A SINGLE STROKE

In Fig. 8 the length of the ordinate between the base line *AB* and the curve, at any point along *AB*, represents the tangential pressure at the crankpin, in pounds per square inch of piston, for the corresponding crank position. The length *AB* represents the travel of the crankpin during one stroke of the engine. Therefore, the area of the diagram *AJB* represents the work done in turning the crank during one stroke, to the same scales of pressure and distance as the indicator diagrams in Fig. 2 represent work done on the piston by the steam.

The load on the engine resists the turning of the crankshaft, and as the load is assumed to be uniform throughout the stroke, it may be considered as a uniform resistance acting at the crankpin to oppose the tangential forces urging the crank ahead. This uniform resistance is indicated in Fig. 8 by the height *AC* of the line *CD* above *AB*, representing 32 lb. It is determined by finding the mean ordinate of the diagram *AJB* and multiplying it by the scale of pressures, 80 lb. to the inch. The mean ordinate, 0.386 in., is found by the same method as the mean ordinate of an indicator diagram.

Since *AC* represents the average resistance and *AB* the crankpin travel during one stroke, the area *ACDB* represents the work done in overcoming the resistance during one stroke. It is exactly equal to the area *AJB*, which represents the work done at the crankpin by the steam during one stroke. A little thought will show that this must be true. For, if the work done at the crankpin by the steam were continually greater than the work of overcoming the resistance, the excess would gradually increase the speed of the engine; and if the conditions were reversed, and the resistance were the greater, the engine speed would decrease. With a uniform speed, the average effort on the crankpin remains equal to the average resistance.

RELATION OF TANGENTIAL EFFORT TO RESISTANCE

The diagram, Fig. 8, shows clearly the relative values of the effort and the resistance at all points in the travel of the crankpin. The constant resistance is indicated by the line *CD*, parallel to *AB*. The tangential pressure, or effort, on the other hand, starts from zero at *A*, increases to the point *J*, and decreases to zero at *B*. While the crankpin is moving through the part of its travel represented by *AK*, the tangential pressure is on the increase, and at *K* it is just equal to the average resistance, as indicated by the crossing of the curve and the line *CD* at *L*. While the crankpin travels from *K* to *M*, the tangential pressure reaches its greatest value, and remains greater than the resistance; but at *M* the two become equal, as indicated by the crossing of the lines at *N*. From the point *M* to the end of the stroke, the tangential pressure decreases, and just before the end of the stroke it becomes negative, as indicated by the slight drop of the curve below the base line.

During the period in which the tangential pressure is greater than the resistance, represented by the travel of the crankpin from *K* to *M*, the excess of pressure is utilized in causing a momentary increase of speed of the crankshaft. During the remaining parts of the half-revolution, the resistance is greater than the tangential pressure, and the result is a momentary decrease in the speed of the crankshaft. If there were no flywheel on the shaft, these periodic increases and decreases of speed on successive strokes would be sudden and violent; but by the addition of a flywheel the fluctuation of speed may be made as small as may be desired.

The crankshaft alone, because of its relatively small diameter and weight, could very quickly be speeded up or slowed down; but a flywheel, because of the weight of its rim and the distance of that rim from the center of the shaft, cannot be speeded up or slowed down quickly by a force acting at the end of the crank. In an engine with a flywheel, therefore, the variable tangential pressure produces only a small change of speed of the crankshaft and flywheel. The speed increases slightly while the tangential pressure exceeds the resistance and decreases slightly while the resistance exceeds the tangential pressure. The total variation between the greatest and the least speed is regulated by the weight of flywheel. The heavier the wheel the smaller will be the fluctuation of speed, because the excess of tangential pressure or resistance has less effect on a large weight than on a small one.

FLYWHEEL ABSORBS AND GIVES UP WORK

Work is required to set any body in motion or to increase the speed of a body that is already in motion, and these statements apply to the flywheel of an engine. While its speed is increasing, work is being done on it and is being stored in it; and while its speed is decreasing, it is giving up work that has been stored in it. The flywheel simply absorbs the excess of work while the tangential pressure exceeds the resistance, and gives it back while the resistance exceeds the tangential pressure.

In the diagram, Fig. 8, the area *LJN* represents the work that is stored up in the flywheel during one stroke, and the combined areas *ACL* and *NDB* represent the work that is given up by the flywheel during one stroke. As the average speed does not change, the work absorbed is equal to the work given up; that is,

$$\text{area } LJN = \text{area } ACL + \text{area } NDB$$

The loop below the line *AB* has been neglected because it is so small; but if it were large, it would need to be taken into account. It would form a part of the area *NDB*; and in calculating the mean height *AC*, the area of the loop would be subtracted from the total area above *AB* and the remainder would be divided by the length of *AB*.

The scale of vertical distances in Fig. 8 is 80 lb. to the inch. The length *AB* is 3.14 in., or the length of the semicircle in Fig. 6, which represents half the circumference of the crankpin circle. As the stroke is 2 ft., half the circumference of the crankpin circle is

$\frac{1}{2}(3.1416 \times 2) = 3.14$ ft. Therefore, each inch of length of *AB* represents 1 ft. of travel of the crankpin. Each square inch of area *LJN* then represents 80 × 1 = 80 ft.-lb. of work per square inch of piston area. The area of *LJN* (found by multiplying its mean ordinate by the length of *LN*) is 0.34 sq.in., and the area of the piston of the assumed engine is $0.7854 \times 18^2 = 254.5$ sq.in. Consequently, the area *LJN* represents

$$0.34 \times 80 \times 254.5 = 6922 \textit{ ft.-lb. of work}$$

which is alternately absorbed and restored by the flywheel during each stroke of the engine.

It is customary, except in very accurate work, to consider that the flywheel rim does all the regulating of speed during the stroke, and to neglect the steadying effect of the arms and hub, which assist the rim. Consequently, the problem resolves itself into finding the diameter and cross-section of rim that will take up and give out the calculated excess of work. The weight, however, depends on the amount of speed variation allowable, which in turn depends on the class of service for which the engine is intended.

COEFFICIENT OF SPEED VARIATION

If the engine is to drive alternating-current generators, the speed of rotation must be very steady throughout the stroke, and the total variation should not exceed $\frac{1}{300}$; that is, the variation in speed of a point on the flywheel rim, between the greatest and least speeds occurring during the stroke, should not be greater than $\frac{1}{300}$ of the average speed of that point. The fraction that represents the ratio of the total speed variation to the normal speed is called the coefficient of speed variation. For various classes of service it may be given the following values:

Engine to Drive:	Coefficient of Speed Variation
Pumps	$\frac{1}{20}$ to $\frac{1}{30}$
Machine-shop tools	$\frac{1}{35}$ to $\frac{1}{40}$
Looms and paper mills	$\frac{1}{50}$
Spinning mills	$\frac{1}{60}$
Direct-current generators	$\frac{1}{100}$ to $\frac{1}{150}$
Alternating-current generators	$\frac{1}{300}$

The weight of flywheel rim required to absorb and give up a known quantity of work may be found as follows:

Rule: Multiply the foot-pounds of work absorbed and given up per stroke by 11,750, and divide the product by the product of the coefficient of speed variation, the square of the number of revolutions per minute, and the square of the mean diameter of the flywheel in feet. The quotient will be the weight of rim in pounds.

In the case of the engine assumed, the flywheel diameter is not stated, and so a value must be given to it. Suppose that a mean diameter of 4 ft. is chosen; that is, the average of the inside and outside diameters of the rim is 4 ft. Assume further that the engine is to drive machine-shop tools. Then its allowable coefficient of speed variation may be taken as $\frac{1}{35}$. Applying the rule, the weight of rim required under these conditions is

$$\frac{6922 \times 11,750}{\frac{1}{40} \times 250^2 \times 4^2} = 3253 \textit{ lb.}$$

Ordinarily, flywheels are made of cast iron, which weighs about 450 lb. per cu.ft. The volume of the rim, therefore, is

$$3253 \div 450 = 7.23 \textit{ cu.ft.}$$

The mean circumference of the rim is $3.1416 \times 4 = 12.57$ ft.; hence, the cross-section of the rim must be

$$7.23 \div 12.57 = 0.575 \textit{ sq.ft.}$$

The area of cross-section in square inches is then

$$144 \times 0.\ 75 = 82.8 \textit{ sq.in.}$$

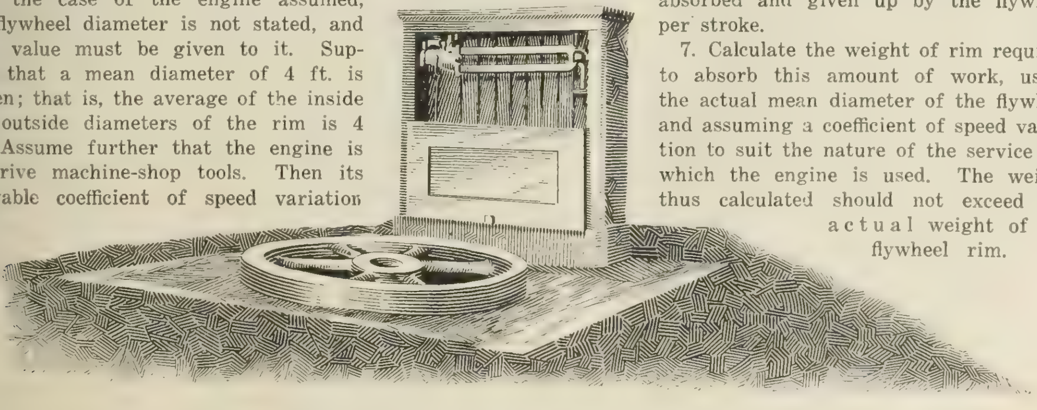
A rim of rectangular cross-section 8¼ in. wide and 10 in. deep will have a cross-sectional area of 82.5 sq.in.; therefore, a flywheel with a rim having a mean diameter of 4 ft. and a section measuring 8¼ in. wide and 10 in. deep will be suitable for the given engine under the conditions assumed. The outside diameter of the rim will be 4 ft. 10 in. and the inside diameter 3 ft. 2 in.

If the engine is already built and in use, the weight of the flywheel may be checked by using practically the same method as that just described. First calculate the actual weight of the flywheel rim as follows:

Rule: Multiply 10 times the mean diameter of the rim in feet by the width of the rim and the depth of the rim, both in inches. The product will be the weight of the rim in pounds.

Next, calculate the weight of the rim by the method outlined in this article, which may be summarized as follows:

1. Take a pair of indicator diagrams from the engine under the normal working conditions.
2. Combine the two diagrams so as to obtain a diagram of net forward steam pressures on the piston.
3. Calculate the inertia forces at several points in the stroke and construct the inertia-force diagram.
4. Combine the inertia-force diagram with the diagram of net steam pressures on the piston, producing a diagram of net pressures on the crosshead pin.
5. From the diagram of net pressures on the crosshead pin, calculate the tangential pressures and draw the diagram of tangential pressures to a semicircular base and then to a straight base.
6. On the straight-base diagram, find the area of that part of the diagram above the line of average resistance, and calculate the total number of foot-pounds of work represented by it, which will be the amount of work absorbed and given up by the flywheel per stroke.
7. Calculate the weight of rim required to absorb this amount of work, using the actual mean diameter of the flywheel and assuming a coefficient of speed variation to suit the nature of the service for which the engine is used. The weight thus calculated should not exceed the actual weight of the flywheel rim.



When Doctors Disagree—I

BY JOHN S. CARPENTER

A bargain-counter installation of water turbines fails to come up to the guaranteed efficiency and precipitates a lively argument between the engineer of the plant and the representatives of the builders.

THE chief laid down his copy of *Power* with a smile and slid it across the big double-ended desk to Bill, his assistant.

"I see the big guns is at it again, tooth an' nail, this time it bein' over a mere trifle like findin' the total flow of a stream by means of velocity measurements. One gentleman says that another member of our learned profession is fulla soup, to put it mild, an' somethin' tells me they's gonna be blood, hair an' the ground tore up.

"It reminds me of the time when they put in the first turbines in this plant, some six years ago. We had a little time here then that would make a New York City mud-slingin' election green with envy. It seems that our president, a darn good drygoods dealer, got an idea to buy generatin' equipment the way he bought drygoods. He thought he saw in one company's bid a hand-me-down-suit marked 'Take me home for $11.88,' an' it took him just five minutes to do it. When that salesman walked out with the contract signed and with a check for one-third of the price in his pocket, I thought I saw a Baxter Street glint in his eye.

"WELL, THROW IT OUT IF IT'S LAYIN' DOWN ON THE JOB!"

"It all went well until they got the turbines in and about three-quarter load on 'em. Then we opened the gates wide to get full load, an' to the surprise of everybody the ammeter needle didn't budge ten amperes. Our drygoods-store president was still struttin' around congratulatin' himself on what a good bargain he drove until he saw my face. He says, 'Whatsa matter, chief?' an' I pointed to the ammeter, it never occurrin' to me that that bird couldn't tell the time on that kind of a clock an' that he didn't know whether amperes is a new kinda grease or divvydends in embryo.

"'Well,' he snoozles, wavin' his fat hand, 'throw it out if it's layin' down on the job!'

"He got told that I'd darn sooner b'lieve that thing than lotsa preachers, an' he looks at me like I had rats in the attic. Them turbines," I says, "is doin' all of three-quarters of what they oughta, an' he asks if we can take 'em back and exchange 'em. After it percolated through his dome that it prob'ly would cost him about ten thousand to do it, he turned a sickish-lookin' green around the gills. Then the real fun began. I called the turbine company's man over to me an' told him to put full load on them turbines. He looked at the gate-openin' indicator, waltzed over to the meters, an' then beat it out on the bridge to see if they was any water comin' outa them draft tubes. They sure was. The discharge comin' outa them concrete draft tubes was the best-lookin' imitation of a spiral staircase that I ever did see, an' made you dizzy to look at it. Then he says that them turbines must be suckin' air an' I took off a manhole cover in the floor so he could squint down an' see them turbines purrin' like cats at liver.

"THEM BOYS, BILL, WERE THE ENGINEERS"

"After he excused himself to go an' wire the office the glad tidin's, he didn't show up for a week. Then he brought up the heavy artillery, consistin' of a man an' two boys. He introduced the man to me as their sales manager; an' b'lieve me, Bill, all that that bird ever did here was to dictate five- and ten-page letters to the public stenographer at the hotel.

"Them boys, Bill, were the engineers. One of 'em I named Flossy right off the bat, an' that guy looked like he just throwed up a job posin' fer them collar advertisements in the trolley cars. The other gink was fastened at the nose to a pair of 42-centymeter shell-rimmed glasses an' prob'bly got 'em fer bein' a walkin' advertisement fer some optician who found that he had thirteen of that kind in stock an' gave him one to break the spell. I named him Omar, after the bird that wrote the Roobiyet an' cashed in over the problem of namin' a new cigarette.

"When them fellers got their circus clothes off, they went over the whole plant from the log boom down to a place a mile below the plant. They fin'lly comes to a decision that the whole trouble is because them contractors left a little colyum in the middle of each of them draft tubes fer fear that the beams inside was still a little green. They tells me that we can never expect to get any more power from them turbines because we got them colyums there. But I noticed that they didn't seem to be crowdin' me to take 'em out.

"Their sales manager made a grandstand play outa that an' asks our president to call a special meetin' of the board of deerectors so he can tell 'em what's wrong, an' get 'em to vote to pay the balance of the contract. When they all got together, I was called in too. They was just an even dozen of us around the table, an' after the preliminaries was run, that sales manager got up an' addressed us in excellent Chinese. The way he talked to them trustin' deerectors about hyperbolic draft-tube curves an' the net total results of twenty years' tests on obstructions to flow by bridge piers was tearful. I betcha all the time he was readin' from some patent-medicine almanac, windin' up by hopin' that we would see the thing impartially an' keep the fair name of the great company he represented unsullied in these parts. Then he sat down an' hinted to Sam Scroggins that an adjournment was in order. But I gives Sam the high sign an' gits up on me hind legs. I said in plain Buckeye that I was darn sure that them colyums never eat up nothin' like a total of a thousand kilowatts an' offered to bet him a hundred iron men in the presence of all them there gentlemen, that if I cut out them colyums that we would'nt get more than a hundred kilowatts more for the whole plant at the contract head. That spilled the beans fer the day.

"His Nibs wasn't what you'd call crazy to take me up, but musta figgered that if he did lose that he could charge it to travelin' expenses or entertainment, so he fell fer my bait. A second thought told me that if I lost I'd have to put a plaster on the house to raise the coin. But the board told me to go an' use the best judgment I had, so I cut 'em out.

"Well, Bill, you oughta seen what happened. The night of the day that them contractors got through cuttin' out them colyums was a rather sleepless one fer me. I was wishin' to the Powers That Be that I bet that ribbon-counter sport it would be two hundred kilowatts more instead of one hundred; but the beans was spilled an' I had to face the music, an' maybe have that ballroom flower kid me about it, too.

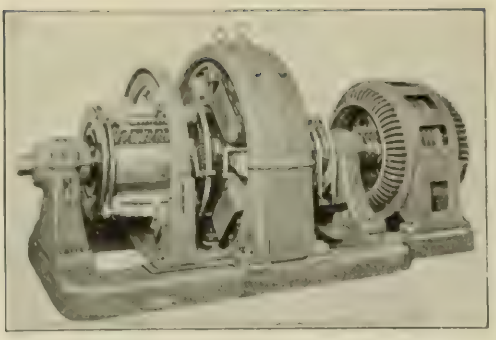
"The next mornin' I snuck down to the plant so early that I caught the night operator gettin' in his best licks at a beauty sleep. He jumped when he saw me like I was a spook, an' I told him to get back in his coop. I throwed all the load I could on one unit by cuttin' out the governor an' usin' the hand regulatin' gear to tear her wide open, lettin' the governor on the other unit take care of the load changes. With that riggin' I got what made 175 kilowatts better for the whole plant, an' me gettin' more an' more scared to death as I sees the needle climb. My hands had that cold, clammy feelin' so popular with corpses an' things like that, an' my voice was that cracked you'd 'a thought it was made of crockery. While I was still havin' them cold sweats, I takes a peep at the head gage; an' say! if Hop Sing, the laundryman, had been there I'd 'a fell on his neck an' kissed him! That gage showed two feet more head than the contract head, makin' a net gain due to takin' them colyums outa them draft tubes of fifty kilowatts! I felt so good after that that I went back to the night operator with the plaid hair an' big fam'ly, who thought he was fired sure, an' tells him with tears in my voice that I was surproozed at him, havin' no higher aims in life than to sleep when his trustin' boss was usually still in the clutches of Morpheus.

"Bill, after I collected that hundred offa that animated fashion plate, the turbine company put in new runners which gave way more than the contract power. Then it was the thing to find out if they got the contract efficiency. The company's engineers, Flossy an' Omar, made tests on the plant an' said that they got 5 per cent. more efficiency than the contract called for, makin' 85 per cent. The contract had the efficiency specified for the full rated load, so we were safe, an' which was 80 per cent. When the heavenly twins said that they got 85 per cent. it made me take another chew an' stew over it a bit. I fin'lly told 'em that we'd get another engineer to check their results before we paid the balance on the contract, an' it kinda got their goats, but they didn't let on. The next day I went an' got me a stop watch an' made some tests on me own hook that I could depend on.

"They is a stretch, as you know, Bill, about four hundred feet long below the plant that is tolerably straight, an' it ain't more than a hundred feet from the end of them draft tubes to the beginnin' of that stretch. Now that channel takes all the water from them draft tubes an' I'm pretty sure that they ain't no springs or other things runnin' into it. About half a mile above the plant there's a weir, an' with another below the plant, we was hooked up fine fer measurin'.

"I went and got me a good big float, weighted her down well an' saw that she went way below the center of the stream. Then I told a big buck nigger to throw the float in the stream while I stood down at the end of that 400-ft. stretch with the stop watch. When the thing was down in the water I clicked the stop watch an' timed it till it got down to me. Now, Bill, I got that coon to throw the float in at a different place every time, beginnin' with the left bank and workin' gradually over to the right bank, an' I got the time every trip. I was always careful to do this work when I was sure that the load was constant enough to have the work right, an' had the operator yell out if the governor moved much during the time I was measurin'. Finally I got a whole raft of timin' and I averaged the whole thing. From my dope on the distance an' the cross-section of the stream at a few places, you see I got the water quantity, but which had to be checked against the weir first. I have an old formula that says with a surface float I must use a constant of about 83 per cent. as a velocity coefficient, but with a subsurface float like I was usin' the constant is about 98 per cent. A table in a handbook was all I needed for the weir, and comparin' it with the float work showed that the coefficient was about 2 per cent. high, but that is of course assumin' that the weir is exactly right, which it ain't. The Francis formula for weirs gives results within 3 per cent. of the truth, accordin' to the best observers. Now, havin' the generator efficiency from the builders, it was easy to get the efficiency of the turbines. All I got was 78 per cent., while the contract called for 80 per cent."

(The remaining installment of this story tells how the stream flow was measured and checked by weir, float and current meter, and how the plant engineer proved that the turbines were not living up to the guaranteed efficiency.)



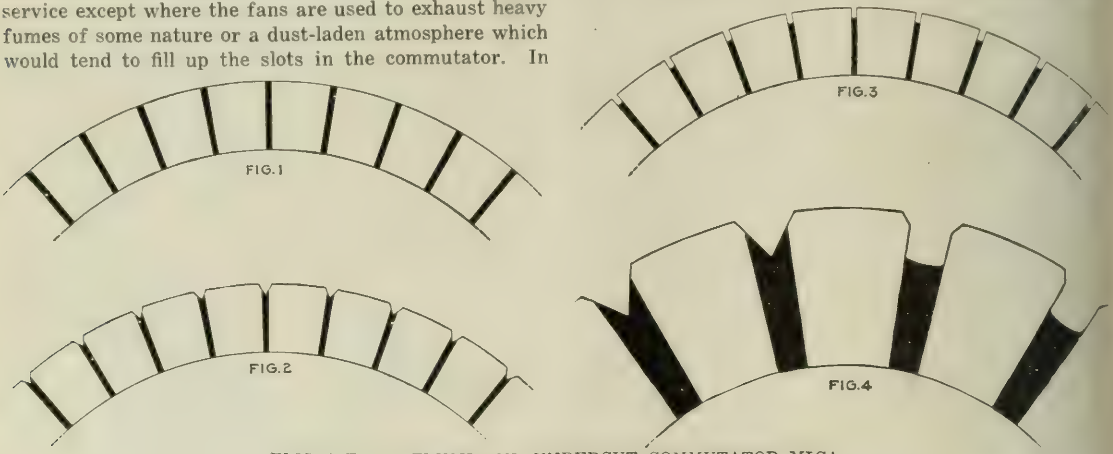
Application of Brushes to Electrical Machinery

By WARREN C. KALB

In the application of carbon brushes the selection of the most suitable grade is frequently influenced by conditions peculiar to the service on which the brush is to be applied. Discussion of these conditions in relation to a few special fields of service gives an idea of some of the points that must be considered.

IN GENERAL factory service the characteristics demanded of brushes are determined more by the type of motor on which they are to be used than by any peculiarities of the service. In nearly all factory service undercutting of mica on the commutators is permissible and is strongly recommended. This permits the use of nonabrasive electrographitic brushes, which insures the longest brush life and the most satisfactory commutation service in every respect.

Ventilating motors usually operate at rather high commutator speeds and should be equipped with brushes possessing low coefficient of friction. The practice of undercutting commutators is to be recommended in this service except where the fans are used to exhaust heavy fumes of some nature or a dust-laden atmosphere which would tend to fill up the slots in the commutator. In such cases it may be advisable to use flush mica, as in Fig. 1, and a slightly abrasive brush.



FIGS. 1 TO 4. FLUSH AND UNDERCUT COMMUTATOR MICA

Motor-driven centrifugal pumps offer no special requirements provided the pumps are not overloaded. It frequently occurs that a pump is required after installation to deliver a head considerably greater than that for which it is designed or than that under consideration when the motor was applied. In such cases the motor may be heavily overloaded, and this factor must be taken into consideration in selecting the commutating characteristics and carrying capacity of the brushes which are to be used.

On motors driving reciprocating pumps, particularly where the gearing happens to be of such ratio that the end of the stroke always occurs when the brush is bearing on the same spot on the commutator, it is sometimes desirable to use a slightly abrasive brush even on motors with undercut mica, otherwise some spotting of the commutator is likely to take place in time.

The almost universal practice on electric railways at the present time is to undercut the mica of the commutators. By this means the need for an abrasive characteristic in the brush is largely eliminated. It also becomes necessary to avoid the use of a brush impregnated with lubricating treatment, as this material has a tendency to fill up the slots of the commutator, causing short-circuits and resultant armature trouble. Brushes can be rated considerably higher in carrying capacity for this service than for classes of service where they are in continuous operation over long periods. Probably 50 per cent. above the normal rating of a brush will give a satisfactory figure for carrying capacity under average electric-railway conditions.

The peripheral speed on railway motors is usually rather high, so that brushes for this service must have good lubricating property. They must also possess considerable mechanical strength and toughness to withstand the vibration they will be subjected to in this application. This is especially true when cars are operated over bad tracks or numerous crossings. The types of brushes now in general use for this class of service are the graphite-carbon class and electrographitic brushes.

Figs. 2 to 4 illustrate various forms of undercutting the mica of commutators. Where there is to be appreciable commutator wear, as is the case in railway service, the square slot, Fig. 3, is preferable. This can be cut as much as ⅛ in. deep for railway motors of high rotative speed where the centrifugal force is enough to clear the slots of most deposit. On lower-speed machines, however, the slot should not be of a depth greater than its width.

On machines that are operated in the presence of a large amount of dust, particularly if it is of a conducting nature, the V-type of slot, Fig. 2, is preferable, because it offers less of a pocket for the collection and holding of dust than is offered by the square type of slot. In all cases it is desirable that the corners of the commutator segments should be slightly beveled, as shown in the enlarged sections, Fig. 4. In the case of the V-slot this insures no edges of mica being left flush with the bearing surface of the commutator, and in the case of the square slot it is necessary to insure the removal of all burrs which might cause rapid wear of the brushes.

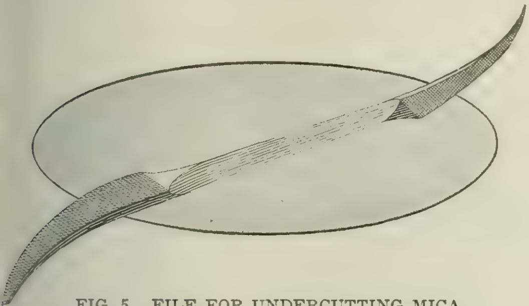


FIG. 5. FILE FOR UNDERCUTTING MICA

The undercutting of the mica may be done with various types of hand slotting tools. Where a V-shaped slot is required, the work can be successfully done with a commutator-slotting file similar to the one shown in Fig. 5. In many of the large shops a motor-driven tool is used, as shown in Fig. 6.

The requirements for generator brushes in steel-mill service are practically the same as those of any power plant, except where the presence of gases tends to corrode the commutator. In this case there is need of somewhat more polishing action in the brush than is required for a generator operating in clean atmosphere.

In regard to the motors about a steel plant, the rapidly increasing practice of undercutting mica in the commutators permits the extensive use of graphite-carbon brushes and the various electrographitic grades. In mills where the practice of undercutting has not been adopted, the carbon-graphite type of brush finds a general application.

Conditions about mines as they relate to the application of brushes are about the same as in steel mills, except that they are more severe in the average mine. This greater severity is due to a variety of conditions, among them being less stable mounting for the average machine, resulting in greater mechanical vibration, the presence of considerable moisture, which has a deteriorating effect on the insulation of the windings as well as preventing at times the undercutting of commutators, and the inferior class of help that will usually be found in charge of the electrical equipment of isolated mines as related to that about steel mills. Carbon-graphite and graphite-carbon types of brushes have an extensive application in this service, and the harder grades of electrographitic brushes give excellent results where commutators are undercut.

The peculiar condition encountered in cement-mill service, which distinguishes it from that in other industries, is the presence of an abrasive dust, which makes the use of a lubricated brush inadvisable. Slotting of commutators is permissible in cement mills provided the slotting is not too deep. The maximum depth to which it is advisable to undercut mica on machines that are operated in an atmosphere such as that found around the average cement plant is $\frac{1}{32}$ of an inch.

The use of an insulating varnish or paint in the slots of the commutator is recommended on motors that are to be operated under conditions where there is a possibility of the slots becoming filled with a conducting material. This practice will prevent short-circuiting of the armature and still retain all the advantages of the undercut commutator. The presence of the abrasive dust around cement mills makes possible the use of nonabrasive brushes on flush mica, in many cases where undercutting of the mica or the use of an abrasive brush would be required in other classes of service.

As was pointed out in the discussion of electrographitic and metal-graphite grades, the former type of brush possesses considerable advantage over the latter for collector-ring service under such conditions as are encountered in a cement mill, provided the current density in the brushes is kept within the range of the carbon brush. The increased slip of induction motors due to the use of the latter type of brush offers no disadvantage in this case, as close speed control is not essential on the type of machinery used in this service.

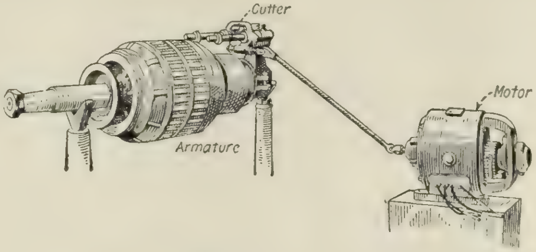


FIG. 6. POWER-DRIVEN TOOL FOR UNDERCUTTING COMMUTATOR MICA

The distinguishing characteristic of service about electrolytic and other chemical process plants is the corrosion of commutators due to the fumes from acids and other chemicals. Undercutting of the mica is advisable on all machines in such installations, and even with the mica undercut the use of a brush possessing some polishing or even a slight abrasive characteristic is advisable. Without undercutting it is often found necessary to use a brush of considerable abrasiveness in order to avoid high mica and the troubles incident thereto.

As is the case in electric-railway service, it is permissible to use a higher-current density in the brushes on elevator service than in continuous service owing missible to use a higher current density in the brushes is subject. One of the most important characteristics to be considered in the selection of a brush for this service is quiet operation. Where elevators are used in hotels and apartment houses, a very slight brush noise from the motor may be the cause of considerable complaint.

A very low peripheral speed sometimes offers a more troublesome tendency for chattering than speeds that are quite high. This is just what is encountered on an elevator motor immediately after starting and just before stopping, and the task of securing a brush that will operate quietly at these speeds sometimes presents a serious problem. It is important that brushes used for this service must have a low coefficient of friction at low peripheral speeds, which is not true of all brushes that are adapted to high peripheral speeds. For special conditions such as this, it is well to consult the manufacturer of brushes in regard to the selection of a suitable grade.

In selecting a suitable brush for any particular application, an analysis of the operating conditions should be made along the line that has just been indicated and the general type of brush determined which is best adapted to the service conditions encountered. The peripheral speed of the commutator or slip ring on which the brush bears should then be figured as well as the current density within the brushes. The following formulas are of convenience in this connection:

Peripheral speed in feet per minute $= \frac{D}{12} \times 3.1416 \times S$, where D equals diameter of commutator or slip ring in inches, and S equals the speed in revolutions per minute.

Current density in amperes per square inch $= \frac{2I}{N \times W \times T}$, where I equals load on machine in amperes, N equals total number of brushes on machine, W width of brush in inches, and T thickness of brush in inches.

After making these calculations all grades recommended by the brush manufacturer for peripheral speed and current density below those to be met should be eliminated, except for conditions of service such as previously mentioned on railway and elevator motors, where brief periods of operation make it permissible to use current densities above those recommended for continuous service. If commutating conditions are severe, high-contact drop should be made the next essential. Knowledge gained by experience with various types of machines is of great assistance in determining this point, otherwise one must judge by the operation of the brushes on the machine and the fact of whether or not the machine has interpoles.

In general, machines with interpoles or compensating winding may be assumed to have better commutating characteristics than those without. Hardness need not be given much consideration in the selection of a brush unless in relation to quiet operation or to severe mechanical conditions. Abrasiveness, however, is an important characteristic and must be considered carefully in relation to the operating conditions. On undercut commutators little or no abrasiveness is required in the brush, while on commutators with flush mica some abrasiveness is needed in almost every case.

Experience with various grades is the best guide to selection as regards abrasiveness, in view of the fact that there is no unit by means of which brushes can be rated in this respect. As a result of the eliminations here outlined, final selection will probably be brought down to three or four grades. The description of these given in the literature of the brush manufacturer will probably offer the clue as to which is best adapted for the conditions of service under consideration.

Aeroil Thawing Outfit

It is sometimes difficult to remove coal from hopper bottomed cars owing to the frozen condition of the hopper gate during severe winter weather. Engineers had ample experience with this trouble last winter. A handy device, known as the Aeroil thawing outfit and manufactured by the Aeroil Coal-Thawing Outfits, Inc., No. 1 Broadway, New York City, has been designed to meet the needs of those who receive coal in carload lots for a means of thawing frozen coal cars rapidly and at a minimum cost. The outfit is portable and can be placed under a car in a few minutes and shifted about as desired. The fuel used is kerosene oil, and the consumption is from 2 to 5 gal. per hour. The illustration shows the application of the device.

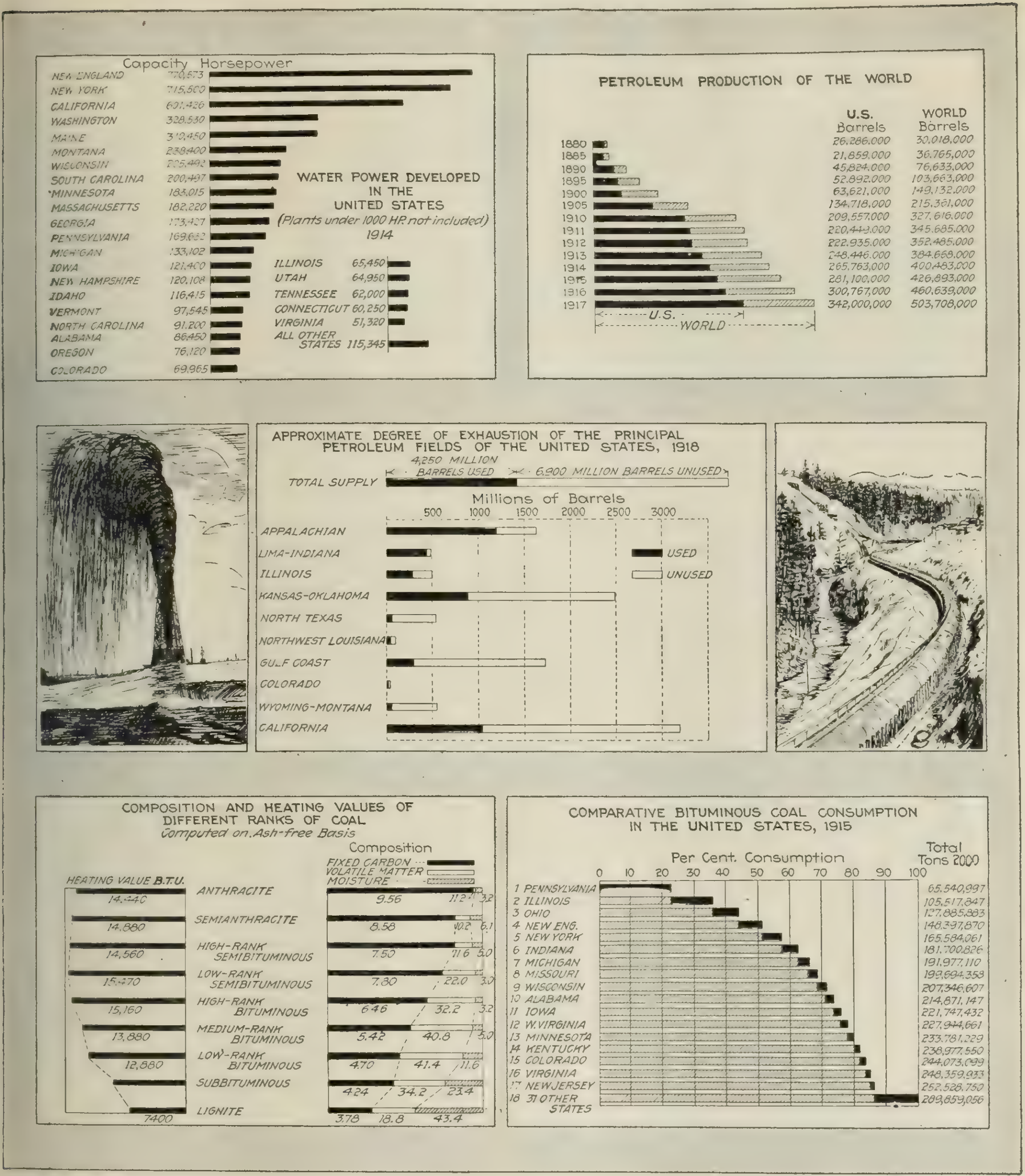
THAWING FROZEN COAL-CAR HOPPERS

The outfit consists of a 10-gal. tank equipped with a hand air pump, pressure gage, air release or regulating valve, and filling nipple with cap; two lengths of 8-ft. rubber hose with unions, two extension pipes with connections, and two thawing burners.

The flame can be directed at such a distance and in such a manner that only the hot air preceding the flame strikes the gate and surrounding woodwork, in case it is used.

No appliance about a power plant receives such lack of attention and such abuse as does the ordinary boiler-feed pump. It is put in an out-of-the-way place, and is generally in charge of a careless fireman who gives it no attention so long as it will pump the necessary supply of feed water. As the ordinary feed pump will consume a great many pounds of steam in the course of a year and as so much depends upon its reliability and continuous operation, it would seem that it would pay the chief engineer to place it in the care of some one who would be held responsible for its condition. If this were done, a vast improvement would result.

Coal, Oil and Water-Power Statistics

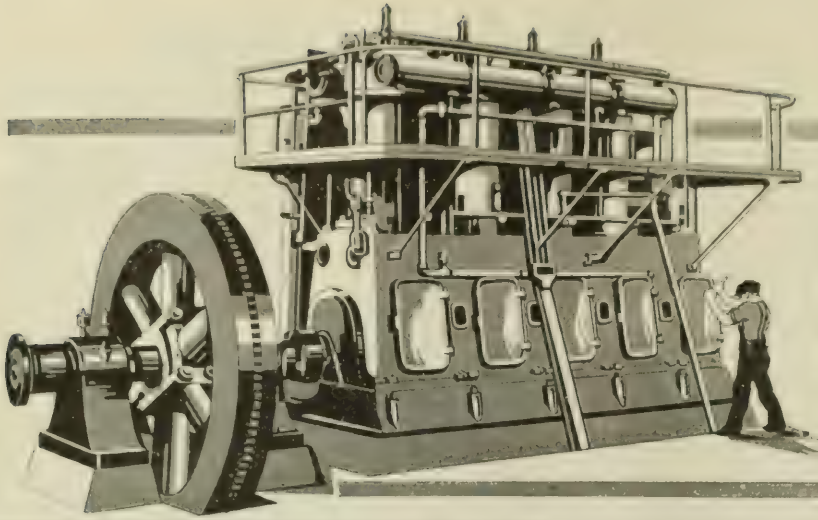


CHARTS SHOWING WATER-POWER DEVELOPMENT, COAL AND PETROLEUM PRODUCTION IN THE UNITED STATES

WHEN the next report of the Bureau of the Census is issued some time soon, it likely will show a material increase in water power, particularly for some of the Southern States. The water-power chart shown here was presented before the Pan American Scientific Congress. The chart giving the petroleum production of the world is from the National City Bank of New York. The others are by the Geological Survey.

It is of interest to note from the chart in the middle of the page that the exhaustion of petroleum has about reached one-half of the ultimate principal supply. Discovery of new fields may, however, seriously upset these figures. The figures do not, so far as can be determined, include oil deposits in shale.

The last chart starts with Pennsylvania, and each state is added to those preceding in the order of its consumption.



Talks on DIESEL Engines

by L.H. Morrison

VIII—The talk turns to a discussion of the various causes of cracked cylinder heads, and Egan tells a story with a dramatic ending.

"WHAT'S the subject for discussion tonight?" Kelly asked as the chief settled into his chair at the table.

"Cylinder heads," Egan answered. "It's one of those things that might be covered in a few words or expanded into a whole evening's talk. You can divide cylinder heads into two classes—the simple and the complicated. Here is a simple form, with a sectional view of it." He spread out the illustration shown in Fig. 1. "You can see it's free of irregularities that might cause shrinkage strains. This style is being largely adopted for vertical engines. The style shown in Fig. 2 is common practice in horizontal engines. It is easy to see why this one can't be symmetrical."

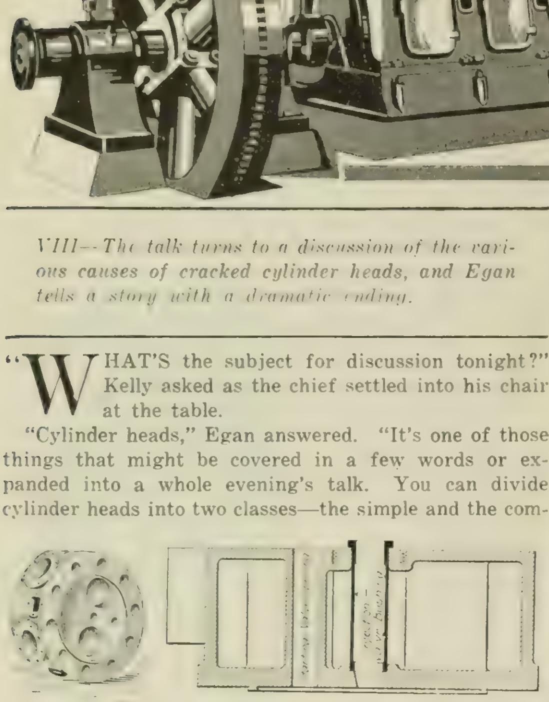


FIG. 1. CYLINDER HEAD FOR VERTICAL ENGINES

"It isn't so easy," Woods contradicted. "I don't get it, quite. Would you mind explaining why?"

"Not at all," replied Egan. "That's what we're here for. Now, you can see that if the valves are set in a vertical position the head cannot be as short as in Fig. 1. You must have room along the sides for the valves. If the compression is to be kept up to 550 lb., the clearance volume in the head cannot be large. Consequently the inner surface must be made conical in order to give room for the valves and still have a small volume of the combustion chamber." "Why not set the valves horizontal?" demanded Woods. "Too much wear on the stems," was Egan's prompt reply. "Even in a gasoline engine horizontal valve stems wear rapidly; but in a Diesel, where the pressure runs so high, the wear is much faster. And the result is that the valves do not rest central on their seats."

He paused a moment to relight his cigar.

"Getting back to complicated cylinder heads," he went on, "I don't think it's internal strains that crack them. It's my opinion that the cooling water gets into dead corners or pockets and becomes so hot that it deposits scale on the metal. The deposits at these points"—he indicated the points marked *A* in Fig. 2—"may become quite heavy. Under the alternate heating and cooling it is liable to loosen in a chunk and suddenly expose the hot metal to the cool water, with the result that a crack is developed. This isn't just a theory of mine. I know of more than one case where cracks occurred at spots that evidently had just been uncovered. The only way to prevent this trouble is to keep the scale from getting thick."

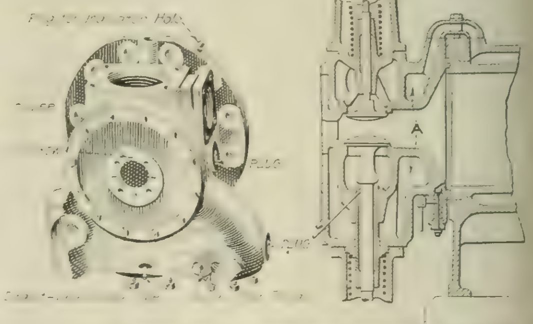


FIG. 2. CYLINDER HEAD FOR HORIZONTAL ENGINES

"Well," Kelly spoke up, "if the head has dead corners and the water has scale in it, hanged if I can see how it's possible to follow your advice."

J. R. laughed at this announcement. "It isn't impossible, by any means," he declared. "If the water is hard, all you need do is to put in a 1 per cent. solution of muriatic acid about once every month and let it stand for an hour. That will cut the scale.

The next article takes up the construction of inlet and exhaust valves and their cages

on't let it stand too long, or it will attack the iron self. Also flush out the entire water jacket every onth with a soda-ash solution. At the Midvale plant he engineer mixes graphite with the cooling water to revent deposits. I know the water at Midvale is bad, ut the last time I was there the jackets and heads were lean, with no signs of scale."

"Why not use water softeners, like they do in steam lants?" suggested Woods.

"Now you've said a mouthful," Egan agreed. "That ame thought has puzzled me. Here is our own comany, supposed to be progressive, with 1500 hp. in iesel engines, and yet it's impossible to get them to onsider a water-softening outfit, although the water is orse than in many steam plants." He flicked the ash ff his cigar with an angry gesture. "The time is comng when the value of accessories will be recognized, nd water-softening apparatus is one of them. It will ut repairs in half, reduce operating expenses and inrease the plant efficiency."

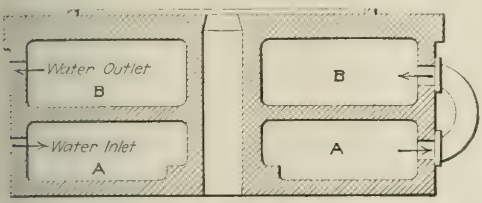


FIG. 3. DOUBLE CYLINDER HEAD WITH WATER CIRCULATION

"If all you said is true," argued Woods, "then the ead of a vertical engine shouldn't crack. But I know f a couple that did, and I'd like to know why."

"That's like telling a horse doctor your mule is dead nd asking him what the disease was," J. R. retorted. I know a case where a vertical engine in a flour mill roke two heads, and it was due to a combination of gnorance and cold water. The mill operates on half ad during the night and about 8 o'clock in the morning arries full load. The cooling water comes from an rtesian well and is around 60 deg. F. Like our own ertical engines this one has the head cooled by a water ne separate from the line feeding the cylinder jacket. rom my observations I believe the engineer opens up he cylinder lines to a full flow as soon as the heavy ad comes on. This water rushing through cools the head uddenly and it lets go, fracturing the wall between the xhaust-valve opening and a bolt hole. With such cold ater the heads should be connected onto the jacket line. he water would be raised by the jacket to around 90 eg. and would enter the head cavity at this temperaure, which would prevent the sudden chilling. A Geran firm got around this by using a double head like ig. 3. The water first enters the chamber *A* and then asses into the chamber *B*. In this way the water next o the hot head is of fairly high temperature and the old current in the chamber *A* helps to keep down the emperature in the chamber *B*."

"Well, what made that No. 1 American Diesel crack ts head the first year I came here?" demanded Kelly.

"Let me sketch the way that head is built," said Egan. e quickly drew the section shown in Fig. 4. "Now this ead connects with the cylinder jacket, and that is one reason there has never been a fracture due to the cooling water. The cause of fracture is the lack of cooling at the exhaust bridge *A*. The hot exhaust gases must pass across this thin iron partition, or bridge, and it expands faster than the rest of the head. Since the head is rigid, the bridge bulges up and when the engine is stopped the bridge cools off and snaps as it cools."

"Kelly was telling how you welded that head, but he was a little hazy as to why you heated it. I wish you would explain that," Woods remarked.

"Well," said Egan, "we had made several attempts to weld the head with an oxyacetylene blow torch, but for some reason the bridge always snapped when it cooled after welding. I decided that this was because the bridge was hot while the remainder of the head was still cold. So I made a furnace out of old grate bars, firebrick and blocks, heated the head until it was red-hot, welded the fractured bridge and let the casting cool. The bridge came out in fine shape. Of course the welding ruined the exhaust-valve seat, so we blocked the head, bored out the seat, and finished it up with a valve-seat reamer. This same process could be used to weld any head. I don't believe it's necessary to discard a fractured head. A new head on an 18-in. cylinder would probably cost five hundred dollars. The entire cost of welding would not exceed a hundred dollars, and the welded head would be stronger because the shrinkage strains would be removed."

"But, Chief," Kelly asked, "is poor circulation the only thing that will cause broken heads?"

"Not at all," answered Egan. "Preignition will do it. If combustion begins before dead-center is reached, the combined effect of the combustion and the compression due to the piston movement may run the pressure up to 1500 lb. per sq.in. The earlier Diesels had relief valves that prevented excessive pressure, but they usually rusted to their seats and refused to budge when they should have acted. None of the engines I'm familiar with have relief valves now, because builders have found that preignition is due to faulty fuel nozzles and poor governing devices. Then, again, a bad casting may cause a fracture—for instance, if a core shifts and leaves a thin wall. But poor water circulation is the chief cause."

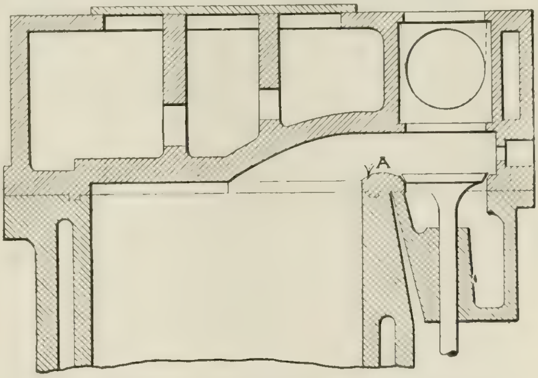


FIG. 4. EXHAUST BRIDGE CRACKED BECAUSE OF INSUFFICIENT COOLING

He smiled reminiscently, and the men saw that a good story was coming.

"I remember a case," J. R. went on, "where a man had a 120-hp. horizontal Diesel running a direct-current lighting plant 18 hours a day in a small town. At midnight he'd close down the plant and go to bed, letting the town get its light from the storage battery. In the morning his boy would start up and run the plant until noon, when the old man would get up and work until midnight. It seems he broke three heads in a year and was kicking hard against paying for them. The builder asked me to investigate the matter, so I ran down one night and early the next morning dropped into the plant just as the boy was starting up. He ran the engine for about twenty minutes before he thought of the cooling-water pump. I came on back and wrote the firm that they'd soon get an order for another head, which they did. So they asked me to run down and tell the old man his trouble. After I explained about the boy's carelessness, the old man picked up a barrel stave and waded into that sixteen-year-old kid for fair. It cured the boy—and it cured the engine, too, for there weren't any more cracked heads."

J. R. was forced to wait until the roar of laughter had died out before he could continue.

"All you boys know how I insist that the cylinder studs have clean threads so that the nuts will run down by hand. I expect at times you've thought the 'old man' a crank about this. But if the nuts can be run down by hand, I'm always sure that the head is being held down at all the studs. When the threads are marred often only a few nuts are ever pulled up snug and so the head never seats properly. At one of the other plants, the nuts at opposite ends of a diameter are drawn up together, a sixth of a turn at a time, so as to get the same tension on all bolts. It's worth trying here."

The Electrical Study Course—Shunt Balancer Sets for Three-Wire Systems

Brings out the fact that balancer sets and three-wire generators have superseded two generators in series for three-wire supply systems and develops the theory underlying the operation of the balancer-set method.

IN THE preceding lessons the sources of voltage for three-wire systems have been shown as two generators of about 120 volts each, connected in series, with a tap taken off their common point, as indicated in Fig. 1. This method was the one used in the early days of power distribution, but it has been supplanted by two others, which are the ones in common use today. One of them employs what is known as a balancer set, and the other a special generator known as a three-wire generator. Of these the former will be taken up in this and succeeding lessons, to be followed by the latter subsequently.

The balancer set consists of two identical machines, which can operate equally well as motors or as generators, and which are directly coupled together. They are used in connection with a separate supply of voltage that is equal to what is required across the outside lines, the voltage of each of the balancer machines being equal to one-half this; that is, the voltage between either outside and the neutral.

The simplest arrangement is the one shown in Fig 2, which represents a 115- to 230-volt system. In it G is a 230-volt generator, and G_1G_2 are two 115-volt shunt machines that are alike in all particulars. The generator G may be far removed from the balancer set G_1G_2, which may be located near the place where the three-wire service is required. Thus, the 230-volt supply may be received from some outside service, and the balancer set installed to make a three-wire system available from it. From the diagram it is apparent that the balancer set really consists of two 115-volt machines connected in series across 230 volts, with their common point n connected to the neutral N and their other terminals connected to the outside lines A and B.

The function of the set is to maintain normal voltage—that is, 115 volts—across each side of the circuit at all times and thus provide a true three-wire system. The theory of operation will be made clear by comparing the conditions existing in the machines while the load is balanced, with those when it is unbalanced.

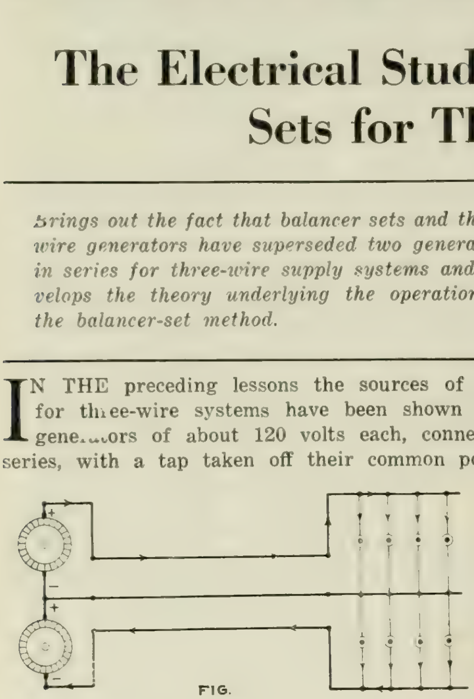


FIG.

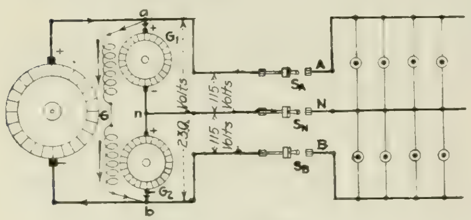


FIG. 2

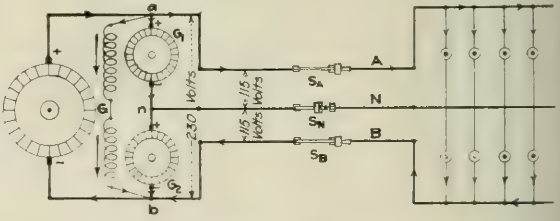


FIG. 3

FIGS. 1 TO 3. DIAGRAM OF CONNECTIONS FOR THREE-WIRE SYSTEM WITH BALANCED LOAD

Suppose, first of all, that the switches S_A, S_N and S_B, Fig. 2, are open, and that the machines G_1 and G have been started as motors connected in series, from the 230-volt mains. Also that the excitation of the two machines is exactly the same so that the voltage across *an* will be the same as across *nb*. Since the voltage across *ab* is 230 volts, that across *an* and *nb* must therefore be 230 × ½ = 115 volts, and the current through both armatures will be the same and will be in the direction of the arrows.

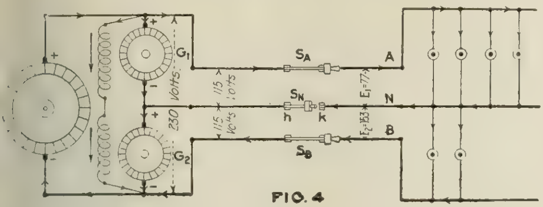


FIG. 4

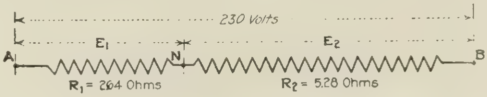


FIG. 5

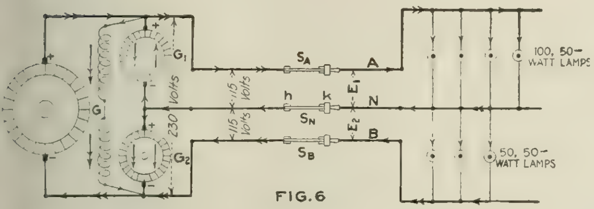


FIG. 6

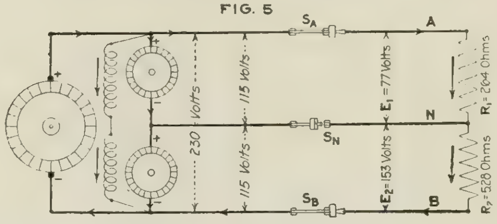


FIG. 7

FIGS. 4 TO 7. DIAGRAM OF CONNECTIONS OF THREE-WIRE SYSTEM WITH LOAD UNBALANCED

Assume now that switches S_A and S_B are closed, but S_N left open, as in Fig. 3. If the lamp load is evenly balanced, the voltages from A to N and N to B will have the same value and will be equal to half the voltage across AB; namely, 115 volts. Under these conditions there will be no difference in voltage across the terminals of switch S_N, and if it were to be closed no current would flow in the neutral N.

Next let us assume that the lamp load is *not* evenly balanced while switch S_N is open, as in Fig. 4; then the voltage across AN will be different from that across NB. This can be most readily shown by a numerical example. Thus, if there were one hundred 50-watt 115-volt lamps across AN and only fifty across NB, we would have the following conditions: The resistance of each lamp would be equal to its current divided into the voltage, that is, $R = \frac{E}{I}$; to find I it would be necessary to divide the voltage into the watts input, that is, $I = \frac{W}{E}\ \frac{50}{115} = 0.435$ ampere. From this $R = \frac{115}{0.435} = 264$ ohms. Since there are 00 lamps in multiple across AN, the resistance connected across these mains would be the resistance of one lamp divided by the 100, or $\frac{264}{100} = 2.64$ ohms, and similarly the resistance across NB would be $\frac{264}{50} = 5.28$ ohms.

We would now have the condition illustrated in Fig. 5, in which R_1 represents the resistance of the lamps between AN and R_2 that of those between N and B. The voltage across AB is 230 volts. The question is, What are the voltages E_1 and E_2 across AN and NB respectively? If I is the current flowing through R_1 and R_2, we will have $E_1 = IR_1$ and $E_2 = IR_2$. To find I we divide the resistance between A and B into the voltage across them, which gives $I = \frac{230}{2.64 + 5.28} = 29$ amperes approximately. We therefore have $E_1 = 29 \times 2.64 = 77$ volts and $E_2 = 29 \times 5.28 = 153$ volts. The voltage of G_1 is therefore greater than that across AN, whereas the voltage of G_2 is less than that across NB, as shown in the figure. The difference in both cases is the same; that is, 115 — 77 = 38 volts and 153 — 115 = 38 volts. This voltage will exist across the two sides of the switch S_N, and a voltmeter connected to *h* and *k* in Fig. 4 will read 38 volts, consequently current will flow through the switch when it is closed.

To study the direction and value of the current reference will be made to Fig. 6. The double arrowheads indicate the direction of the current when switch S_N is open as in Fig. 4. The single arrowheads represent the direction of currents existing when switch S_N is closed. Since A is positive with reference to N and since E_1 is less than 115 volts, it follows that when switch S_N was open the side *k* was at a higher voltage than the side *h*, consequently when the switch was closed current would flow from *k to h*. The same deduction would follow if the voltage E_2 were considered instead of E_1; here N is positive with regard to B and E_2 is greater than 115 volts. Hence again, *k* is at a higher voltage than *h*.

Before the switch S_N is closed, both G_1 and G_2 are running as motors without load and 115 volts exist across each of them, as in Fig. 4. When the switch is closed, we have G_1 connected to a load whose voltage is only 77 volts and it will consequently act as a generator. On the other hand, we have G_2 connected to a voltage of 153 volts, and it will therefore be caused to take current in addition to that required to run it idle. The changes in currents are governed by the elements as brought out in what follows:

Fig. 7 is a simplified version of Fig. 6, using the equivalent resistances of Fig. 5 in place of the lamps. Assuming, for the moment, that the voltage of both machines remains 115 volts when the switch S_N is closed, it is evident that the voltage across R_1 changes from 77 to 115 volts and consequently the current through it will be $\frac{115}{2.64} = 43.6$ amperes instead of 29 amperes as formerly, and similarly that the voltage of R_4 changes from 153 to 115 volts, making its current $\frac{115}{5.28} = 21.8$ amperes instead of 29 amperes. As a matter of fact, however, the voltages cannot remain at 115 volts as they would in the case of an automatically controlled generator and a motor connected to a sufficiently large supply line. When G_1 is converted from a motor into a generator by the closing of switch S_N, its terminal voltage is reduced due to the load upon it, and is therefore less than 115 volts. Since G_1 is running as a generator, it follows that it must receive mechanical power from some source, which in this case is machine G_2. That is, G_2 running as a motor drives G_1 as a generator, and it would therefore tend to slow down, but since the voltage across G_1 is somewhat less than 115 volts, the voltage across G_2 must be as much greater than 115 volts and it will therefore tend to speed up, thus counteracting the tendency of the load upon it to slow it down.

Putting this another way, it may be stated that when switch S_N is closed machine G_2 is thrown in parallel with the lamps from N to B and in series with them from A to N. Then part of the current required by the excess lamps connected from A to N flows along the neutral and through the armature of machine G_2, causing it to have a greater current through its armature than G_1, consequently machine G_2 increases in speed and with it G_1. The counter-voltage of G_1 is made greater than its applied voltage and it becomes a generator supplying a portion of the excess current required by the lamps between A and N. The flow of the current is indicated by the single arrowheads, Fig. 6.

Since both machines must always run at the same speed whatever that speed may be, and since their field currents are the same, it follows that their generated voltages must be practically the same. The generated voltage of the motor G_2 is its counter-em.f. The terminal voltage of the generator G_1 will be its generated voltage minus its internal voltage drop due to armature resistance. Likewise the terminal voltage of the motor will be its counter-em.f. plus its resistance drop. If the load between N and B is made greater than that from A to N, then machine G_1 acts as a motor to drive machine G_2 as a generator.

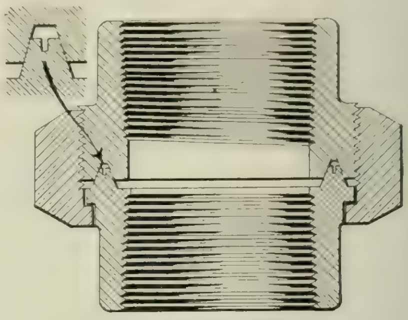
In the problem of last week it was required to find the size wire that it would be necessary to install in a three-wire system that is to supply current to a load of 46 kw. at 115 volts. Since half the load is on each side of the system, there would be a load of $\frac{46}{2} = 23$ kw. between each outside wire and neutral. The number of watts would be $1000 \times 23 = 23{,}000$, and the current equals the watts load divided by the voltage, or $\frac{23{,}000}{115} = 200$ amperes. Looking up the size wire required for this current, as given in the National Code, we find that we would have to use a No. 0000 wire if rubber covered, or a No. 0 if other insulated wire is used.

A 115- to 250-volt three-wire system is loaded with thirty-two 20-watt 115-volt lamps on one side and with twenty-four on the other. What would be the current in each of the three supply wires? Suppose a break to occur in the neutral line, what would be the current in the outside wires and what would be the voltages across the two sides of the system?

Edward Gasketless Double-Tight Union

Troubles with leaking flange gaskets in pipe lines are common. A letter in the Nov. 26 issue of *Power* described how such a joint was made tight by turning a tongue and groove on the faces of the flange, the metal-to-metal joint being made at the heel of the tongue.

A similar idea is found in the Edward gasketless double-tight union, manufactured by the Edward Valve and Manufacturing Co., 72 West Adams St., Chicago, Ill. The illustration shows the construction. It is made somewhat similar to the ordinary type of union, with the exception of the contact joint. One face is grooved V-shape, and the other is made with a split tongue. The faces of the tongue and groove are made with about 2 deg. difference of angle, and the joint is made at the narrow part of the V-groove, which gives a somewhat flexible joint.


GASKETLESS UNION

No gasket or inserted seat is used with the union, and the joint is made doubly tight because of the two separate independent contacts of the split tongue in the groove.

Omaha is contemplating city ownership of its gas plant. The franchise of the present gas company expires soon, and a condemnation court has been appointed to make an inventory and appraisal of the plant. Omaha's water-works system has been municipally owned for six years, and the rate has been reduced about 60 per cent., with excellent service. This has encouraged the city to look toward another municipally owned undertaking.

The quantity of crude petroleum marketed from oil wells and field-storage tanks in the United States in 1918 reached the record-breaking total of 345,500,000 bbl., as shown by preliminary estimates made by John D. Northrop, of the United States Geological Survey, Department of the Interior. This output is an apparent gain of 3 per cent. over the former high record, 335,315,601 bbl., established in 1917.

Water Circulation in Boilers*

By A. D. WILLIAMS

Interesting points are brought out regarding the water circulation in water-tube boilers. Experiments are cited by which the observer can obtain a good idea as to the flow of steam in the tubes with varying degrees of pitch.

OWING to the fact that water may be converted into vapor at rather low temperatures, there is no particular difficulty in constructing a boiler hat will produce steam when heat is applied to it. To-lay there are so many different designs that it would e difficult to enumerate them. A few years ago boilers vere operated and rated at the nominal figure of 10 q.ft. of heating surface per boiler horsepower. Today he nominal rating remains the same, but in practice the oiler is operated at from 150 to 300 per cent. of rating. he water-tube boiler was devised to increase boiler fficiency by securing improved water circulation and reaking the circulating water up into multiple streams urrounded by hot gases. In this they have met a cer-ain degree of success as is proved by the modern method f boiler forcing.

The most widely used design of the water-tube boiler onsists of one or more steam drums and an assemblage f inclined tubes, the pitch or slope varying from 8 to 30 er cent. These tubes are generally arranged in mul-iple, but there are designs that employ series operation f a number of multiple banks of tubes. Circulation enerally depends upon the thermal siphon principle; hat is, upon the hydrostatic head developed by the dif-erence in weight of two columns of water of slightly ifferent temperatures. Additional circulating velocity s supposed to come from the fact that one of these olumns of water is solid and the other partly displaced y steam bubbles.

The accompanying table shows the weights of water nd steam at different temperatures, by 20 deg. C. in-rements, together with the corresponding pressures. At he boiling temperature, 100 deg. C., the ratio between he weights of equal volumes of steam and water is bout 1 to 1600, which is sufficient to supply an ascen-ional velocity to the steam of about 580 ft. per sec. At 00 deg. C. the ratio drops to 1 to 110 and the ascensional elocity to 153 ft. per sec. The coefficient of friction etween the bubble of steam and the surrounding water is unknown, but even if an extremely liberal allowance is made for this coefficient and for the viscosity of the hot water, the steam bubble will rise above any moving stream of water circulating through a tube before it can be carried any great distance horizontally.

WEIGHT OF WATER AND STEAM AT VARIOUS TEMPERATURES

emper-ature, eg. C.	Steam Pressure Kg. per Sq.Cm.	Lb. per Sq.In.	Weights of (Water) Lb. per Cu.Ft.	Water Kg. per Cu.M. Ounces per Cu.Ft.	Steam Kg. per Cu.M.	Lb. per Cu.Ft.	Ratio of Weights. W ÷ S
0	0.00623	0 0886	62 492	999 87	0 00485	0.000303	206,158
4	.	......	62 500	1000 00	....	.	.....
20	0.0238	0.338	62 389	998 23	0 0173	0 00108	57,701
40	0.0749	1.066	62 016	992 25	0 0511	0.00319	19,517
60	0.2028	2.885	61.453	983 24	0.1305	0 00815	7,534
80	0 4828	6.867	60 739	971.83	0.2938	0.0183	3,307
100	1 0330	14.690	59.899	958.38	0.5980	0 0373	1,602
120	2.0240	28 790	58 963	943 40	1.1220	0.0700	841
140	3 6840	52 390	57.900	926.40	1.9680	0.123	471
160	6 3000	89.590	56.719	907.50	3.2650	0.204	278
180	10 2160	145.30	55.413	886.60	5.1500	0.322	173
200	15.8400	225 20	53.925	862 80	7 8400	0 489	110

A simple experiment will permit the verification of the foregoing statement. A glass test tube is nearly filled with water and a smaller tube is used to blow air so it will bubble up through the water. A cork with a vent on one side and a hole for the smaller tube permits the test tube to be inclined to various degrees. The ratio between the weights of equal volumes of air and water is 1 to 774. (When the tube is inclined the vent should be at the upper side, otherwise the apparatus will backfire.) Upon blowing through the small tube it will be found that at the vertical position and at slight inclinations from the vertical, the air will rise in bubbles. This action is utilized in the air lift used in raising water from deep-driven wells. When the degree of inclination approaches the horizontal, there will be a tendency for the stream of bubbles to follow the high side of the tube, and a stream of air can be formed. The less the pitch of the tube the easier it is to maintain this stream of air. This would lead to the conclusion that in the inclined tube design of water-tube boiler the lowest portion of the tube would be filled with water for its full area and at its highest portion the tube would have the lower part of its area filled with water and the upper part filled with steam.

ACTION IS COMPLICATED BY THE BAFFLING

In the boiler, however, the action is complicated by the baffling and the portion of the tube exposed to the hottest gases. With the ordinary method of baffling used with the B. & W. type of boiler, the high end of the tubes is exposed to the hottest gases and this end therefore will be filled partly with steam and partly with water. When the lowest portion of the tube is exposed to the hottest gases, there is a tendency for a portion of the steam generated to pass from the tube to the rear header and up to the steam drum. This action may be avoided by bushing down the rear end of the tube and in this manner increasing the velocity of the water entering to an extent that will enable it to carry the steam with it to the front header.

An experimental single-tube boiler may be extemporized from a gage-glass, a wooden clamp arranged to hold the tube at various degrees of inclination, two pieces of rubber tubing fitted to the ends of the gage-glass and connecting with nozzles on the bottom of a tin pail, a bunsen burner or a blowtorch. The pail should be partly filled with water and supported so that there is space below it to permit the gage-glass to be brought nearly vertical. The heat can be applied to different parts of the water tube and held there until steam begins to form. The evidence of convection currents may be obtained by dropping a few crystals of potassium permanganate in the water near the down leg. As this slowly dissolves, a stream of pink will show the direction of the current. If the water is colored a light pink, it will, in the steaming tests, permit the steam bubbles to have a higher degree of visibility. When the heat is applied at the lower end of the slightly inclined tube, it will be found that a portion of the steam goes up the down leg instead of the up leg. As the inclination of the tube is increased, this tendency decreases until all the steam tends to flow to the up leg and this greatly increases the velocity of circulation. A neat modification of this one-tube boiler has glass up legs and down legs of various lengths, with only short rubber connections between the tubes and to the pail. A number of interesting experiments may be conducted with this simple apparatus, and in this way a better idea of the conditions governing water circulation will be obtained.

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STEAM HAS FRACTIONAL VALUE

The specific heat of water and its heat capacity are unity. The heat capacity of steam has a fractional value, but in contact with water, under the conditions existing in a boiler tube, it has reached the limits of its heat-absorbing capacity for the existing temperature. That is, any additional heat imparted to the steam in the tube will be immediately absorbed by the vaporization of a corresponding amount of the water present. When the water is converted into steam, its volume increases from 110 to 1600 times and it displaces from 109 to 1599 additional volumes of water.

The 4-in. boiler tube has a sectional area of 12.56 sq.in. Its length is about 18 ft. and its heating surface is 18.6 sq.ft. When a boiler is driven at 200 per cent. rating, it is evaporating water at the average rate of 0.29 oz. per 10.764 sq.ft. per sec. On this basis each tube will evaporate 0.49 oz. of water per second, on the average. However, it is not unreasonable to suppose that the lower tubes, directly exposed to the hot gases and radiant heat from the fuel, will have an evaporation rate of, say, ten times the average, or 3.94 oz. of water per tube per second. At a steam temperature of 200 deg. C. this would mean that about 35 per cent. of the internal volume of the tube was occupied by steam. At lower steam temperatures the volume of the steam released will be much greater and fill a larger percentage of the tube volume. It is probable that the lower end of the tube will be occupied by solid water, and if this is the case and the steam is generated uniformly the full length of the tube, 70 per cent. of the area of the highest end will be occupied with steam. Assuming that the pitch of the tube is 30 per cent., this is sufficient to give a head that will impress a velocity of about 18.6 ft. per second on the steam. Friction against the water surface may be either negative or positive, depending on their relative velocities. Friction against the tube surface will reduce the steam velocity.

THE ABSORPTION OF HEAT

The steam in the upper section of the tube will not be able to absorb heat as rapidly as the water in the lower section, but as long as a portion of the perimeter of the tube is covered with water there is no danger of the tube becoming overheated. The hydrostatic head causing the flow of water into the tube will be due to any difference of temperature between the front and rear tube headers and the height of the water column above the tube. Some experiments have indicated that this velocity decreases as the boiler is forced above rating.

Should the flow of water be interrupted, it will require only a few seconds for the tube to become full of dry steam; it would then rapidly heat until it burst. This would throw full boiler pressure against any slight obstruction and immediately remove all evidence of the cause of the trouble. With tube pitches less than that assumed, the liability to interruption in the water circulation increases. The slight differential head that exists through a tube might readily be sufficient to hold a piece of loose scale over the end of a tube and be insufficient to break it. That is, a very slight obstacle would suffice to stop the flow of water or so reduce it that a considerable portion of the tube surface would become dry.

Another reason that may cause burst tubes would be when the boiler is forced to such an extent that the water inflow into a tube becomes insufficient to provide for the evaporation taking place. This last condition would be more likely to occur in a clean tube, free from scale internally and from dust externally, than in a dirty tube.

WATER CIRCULATION ENHANCED BY THE EFFECT OF STEAM BUBBLES

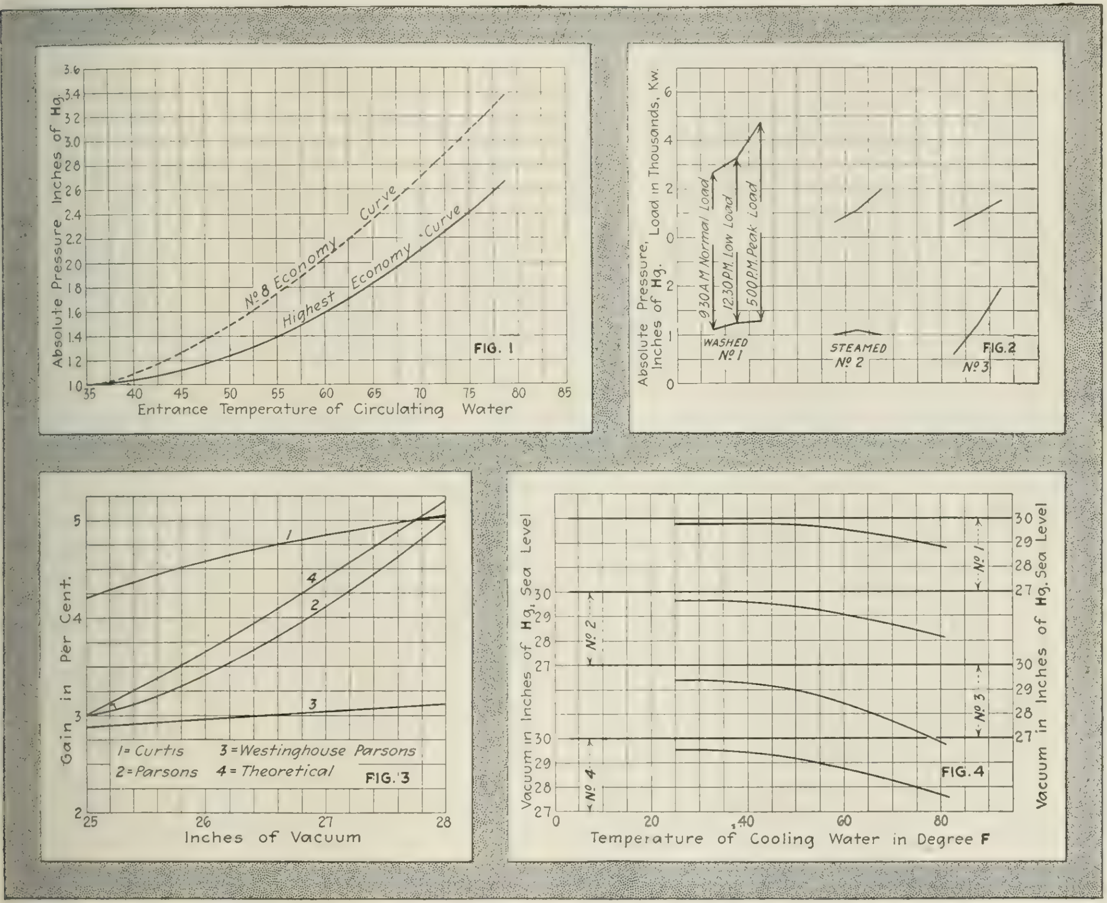
When the boiler tubes are vertical or nearly vertical, the water circulation will be enhanced by the air-lift effect of the steam bubbles. Like the air lift, this is a problem that involves so many uncontrollable variables that it is doubtful whether any rational expression for this circulation will ever be worked out. The investigation of this circulation, however, will throw considerable light upon the rational design of steam boilers. It is very possible that a modification of the design of the Niclausse boiler having the field tubes set vertically, with the manifold at the top, will offer almost unlimited forcing possibilities, greatly exceeding the evaporative capacity of existing designs. Such a design, with an internal tube in each water tube, would be extremely difficult to clean. In any design to secure increased circulation it is rather important that the course of the water and of the steam bubbles should be arranged in such a manner that they will not impede each other. Theoretically, there should be no limitation to the amount of forcing which a vertical-tube boiler can stand except the heat-absorbtion capacity of its heating surface. With inclined tubes the boiler can be forced only to the extent of turning a sufficient amount of water into steam to occupy the full area of the hottest tubes at their highest point. Any further forcing with this type of boiler will cause it to destroy itself.

Exactly what the last word in boiler design will be is hard to say. Present designs leave much to be desired, not only in the circulation of the water but in the manner in which the hot gases pass through the setting and come in contact with the heating surface. The ruling temperature of boilers is very low. Convection currents in water are set up with very low temperature differences, and as the temperature of the mass increases the convection head caused by one degree difference in temperature increases. These physical principles do not cause design difficulties, and it is probably for this reason that boiler engineering has settled into a rut and the mechanical details of the connections entirely overshadow the importance of increasing its heat-absorbing capacity.

Vacuum Trouble in Turbine Condensers*

By JAMES BRAKES, Jr.*

IN THE article, "Keeping Up Condenser Performance," on page 868 of the Dec. 17, 1918, issue, H. LeH. Smith has, in his Fig. 1, plotted absolute pressure against the entrance of the intake circulating-water temperature. Notice that when the temperature of the water is 37 deg. the absolute pressure on No. 5 condenser is 1.18 in. while the pressure on No. 3 is 2.08 in. The former pressure corresponds to 28.8 in. and the latter to 27.9 in. of mercury vacuum referred to 30 in. barometer at 58.4 deg. F. temperature. This gives a difference of 0.9 in. vacuum, which is a considerable variation.



FIGS. 1 TO 4. CHARTS SHOWING CONDENSER PERFORMANCE

Fig. 1—Plot of readings on condenser No. 8. Fig. 2—Curves showing low, normal and peak-load readings. Fig. 3—Percentage of gain in economy per inch of vacuum for various vacuums. Fig. 4—Curves of condenser performance under different conditions

It is necessary that a condenser be overhauled and washed out frequently—at least once every two weeks. The pipe joints and stuffing-boxes should be tightened about the air pump and also the circulating pump. It is a fact that handling air in solution is the smallest percentage of work done by an air pump. The leakage through piping, etc., imposes the greatest duty. The amount of air ranges from ten to thirty times the amount that is dissolved in ordinary water.

On a performance test made by the Turbine Committee of the National Electric Light Association on a 5000-kw. Curtis turbine of the Boston Edison Co., the following is noticeable: The loads on test Nos. 2 and 3 were 3410 and 4758 kw. respectively, with a vacuum of 28.7 and 28.6 in. of mercury. The barometer reading was 29.95 in. A difference of 1348 kw. made a difference of 0.1 in. in vacuum. No doubt the condenser was washed previously to the test, hence the variation of vacuum was due to a great extent to the difference in load.

The writer has an idea that in the case mentioned in Mr. Smith's article the variation in vacuum on turbine condensers Nos. 3 and 5 was due to a drop in the load, air leak or erroneous reading. This is stated, provided the condensers are of the same type and the machines are of the same capacity. No doubt when Mr. Smith asserted that the highest possible plant economy was obtained on the best of the readings, he took the load conditions into consideration. This being true, why should the majority of readings on condenser No. 8 plot as the writer has illustrated by the dotted line in Fig. 1?

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*Testing Department, Commonwealth Edison Co., Chicago, Ill.

From the foregoing it is evident that a plant-economy curve is not really true when based on the results of readings obtained on all the machines, as each machine has its own characteristics.

It is far better to plot a separate curve for each machine and to hold the load constant as far as possible on the machine in question. The best reference curve can be obtained on each machine by plotting the absolute pressure in inches and the kilowatt load separately. If possible, the readings should be taken three times a day and three days a week. It would also help to a considerable extent to obtain the three readings, at low, normal and peak loads. When taking the readings, place *S* or *W* under the curve of each machine to represent whether the condenser is steamed or washed. This can be obtained by observation of the log obtained on the third watch. A set of these curves covering the period of a year will be of some benefit to the chief, especially when the intake-water temperature is stated on each curve, as in Fig. 2.

It also helps considerably to run a water-rate test on a machine occasionally in order to check up its performance as a whole. Moyer states that within the limits of a few inches of vacuum the cost of the turbine is not changed enough to make it a factor in determining the most profitable operating vacuum.

Fig. 3 illustrates the percentage gain in economy per inch of vacuum for various vacuums. A close agreement between the actual and theoretical curves is worthy of notice. The writer recommends F. R. Wheeler as an authority on condensers, and his article on "Condensers and Heater Calculations," which appeared in *Power*, Vol. 40, No. 17, is worthy of careful reading.

DETERMINING VACUUM BEST SUITED TO CONDITIONS

Having the quantity of condensing water required, the cost of fuel and the cost of water delivered to the condenser, the vacuum best suited to the conditions under consideration may be readily determined. Fig. 4 might be of interest to the reader as it gives a set of curves of vacuum at sea level for varying temperatures of cooling water. Fifteen degrees difference between the temperature of the condensed steam and that of the discharge water is usually applicable to modern surface-condenser installations.

No. 1 curve of Fig. 4 gives the theoretical possible vacuum plotted against the temperature of the cooling water. In this case the ratio of the water to the steam is infinite. The results of No. 2 curve take place in a perfect condenser when the ratio of the water to the steam is 60 to 1 and no temperature difference of inlet and outlet cooling water. No. 3 shows an actual condenser at water and steam ratio 60 to 1 with 15 deg. water difference. No. 4 shows an actual condenser working at 15 deg. water difference and 100 to 1 steam water ratio.

Having the temperature of the circulating water in degrees F. and the approximate ratio of the water to the steam, the approximate economical vacuum may be obtained. This is only applicable provided the difference of the inlet- and outlet-water temperatures does not exceed fifteen degrees.

However, it is the opinion of the writer that the kilowatt load should be taken into consideration along with the other factors such as cooling-water temperature, steam consumption, etc., in order to determine the most economical vacuum. It is necessary when carrying the high economical vacuum at high load, to bear in mind that a slight change in vacuum will cause considerable variation in the load. In other words, the meaning of "Watch your vacuum" must be explained to the turbine operator from this point of view.

As the steam expands through the turbine, from boiler pressure to exhaust, its volume increases rapidly. Unless the steam passages become correspondingly larger, congestion of the steam results, with consequent loss of efficiency. It is due to this fact that a vacuum of 28 in. accomplishes little or no improvement over a vacuum of 26 in. when taking into consideration the reciprocating engine. Its low-pressure cylinder could not be designed large enough to expand steam economically, higher than 26 in. Hence, unless the low-pressure buckets and exhaust openings are frequently overhauled and looked after in regard to ample size, little advantage is gained by high vacuum. Stress must be also laid on the peripheral admission of steam on the first and last stages of the turbine.

A variation in vacuum can also take place due to the wear on the turbine buckets caused by the erosive action of wet steam and from the corrosion from impurities in the steam. High superheat will in some cases cause deformation resulting most of the time in interference at the running clearances.

All the facts cited tend to show that in order to locate vacuum trouble, consideration must be given to the turbine unit as a whole, not simply to the condenser and condenser auxiliaries.

In addition to the set of yearly curves as outlined in Fig. 2, a vacuum maintenance record as given by Mr. Smith in his Fig. 2 would be of great service.

COAL WASTE VS. FOOD CONSERVATION

EDITORIALS

Do Technical Courses Need Revision?

MANY of our universities and technical schools suffered serious depletion in ranks through voluntary enlistment and the draft. Coming on top of this, the Student Officers' Training Corps tended toward further disorganization of the courses.

There has not yet been time for the schools to recover from these effects, and many are seizing the opportunity to give serious thought to a readjustment of courses to meet changed conditions, so that a fresh start may be made next fall. In several of the larger institutions these contemplated changes are taking the form of less specialization in the technical courses.

While such plans are under advisement, serious thought might well be given to making the mathematical training more effective. The practice in most of our technical schools is to provide a thorough training in pure mathematics during the first year, but after the student has successfully passed his examinations the subject is put behind him and he breathes a sigh of relief. This is contrary to Continental practice, which, upon graduation, holds the student responsible for the work covered during the whole course.

It is not intended to pass judgment here upon the relative merits of the two systems. Doubtless, each has its advantages as well as its disadvantages. It may be significant, however, that in certain branches of the army requiring applied mathematics many of our reserve officers were lamentably rusty.

Pure mathematics are fundamental as well as useful for training the mind, but they should be supplemented by more applied mathematics given at such time as will make the most lasting impression.

Would not a course in applied mathematics in the last half of the senior year meet the requirements of the case? At this time the student's training has reached such a stage that he is better able to appreciate the relation between the practical and the theoretical, and only such applications need be given as he will be likely to encounter later in the engineering profession.

Water Power in Canada and in the United States

ACCIDENT of geographical location places most of the important industrial and commercial centers of the Dominion of Canada within easy reach of hydro-electric generating stations that are capable of furnishing an abundant supply of power. Because of the remarkably low cost of development, this power is produced economically and the result is a widespread use of electrical energy throughout the Dominion.

As brought out elsewhere in this issue, Canada utilizes two hundred and seventy-six hydraulic horsepower for each thousand of her population. Comparison with the United States cannot readily be made, because the latest figures available for this country are those of 1912. At that time this country used about twenty-five hydraulic horsepower per thousand population. Making an unusually generous allowance for increase of water-power development during the last few years, it seems certain that even now the United States does not make use of one hundred horsepower of hydro-electric energy per thousand population. Compared with our northern neighbor, our per capita utilization of hydro power is only from one-fourth to one-third as great.

The reasons for this apparent backwardness on our part are two: Lack of adequate legislation governing the methods of exploitation and higher costs for development and transmission. Congressional action on the Administration Water-Power Bill has been delayed for months, despite the need for increased supplies of power, and the indications are that nothing conclusive will be accomplished during the present session.

Those localities which would benefit most from a prompt and properly safeguarded development of water power have not forgotten the matter, however. The Northwest, which contains some of the most desirable water-power sites in the country, is loud in its protests against the dilatory methods being pursued at Washington. Senators and Representatives are being bombarded with letters from their constituencies declaiming against the policy of inactivity. Congressional inertia is proverbial, but it must eventually yield to the urge of national necessity.

Government-Owned Machine Tools for Industrial Training Schools

BETWEEN two and three hundred million dollars' worth of machine tools were purchased by the Government for war work, and now that they have served their purpose, the problem of disposing of them to the best advantage is being considered. According to the terms of the appropriation bill under which they were bought, they must be sold so as to bring the greatest possible return to the Government, but there are serious objections to such a procedure.

Perhaps a third of the tools can be installed in existing arsenals. To throw the remainder on the market to be sold at sacrifice prices would practically demoralize the machine-tool industry; for most of the machine shops of the country are already supplied—even overstocked—with tools. Thus, building of new tools would come to a standstill and workmen in that field of labor would be added to the lengthening line of the unemployed.

A plan has been suggested whereby such adverse conditions may be avoided, and a bill has been introduced in the House to enact the project into a law. Briefly, the bill proposes that the Secretary of War shall be empowered to lend these machine tools to trade and technical schools, colleges, universities and other educational institutions that in his judgment should have such equipment. Adequate provision is made to protect the interests of the Government by making each institution thus equipped responsible for the proper care and safe return of the tools when they are demanded, ordinary wear and tear excepted.

The passage of this bill is desirable, for it will provide means for the industrial training of the children of those who have bought and paid for the machinery. At the same time the Government will be relieved of the expense of storage charges and the material will always be subject to immediate recall if it should be needed in the event of future war.

Beware of comparative figures unless they are reduced to the same basis. A boiler with a certain evaporation per pound of coal may be considerably less efficient than a boiler with a lower evaporation, a higher steam pressure and colder feed water.

The appearance of power-plant equipment is a good index of whether the man in charge takes interest in his job and knows his business, for thorough grooming is the first requisite of careful inspection to obtain knowledge of the conditions.

Supplying the fireman with coal and telling him to keep up steam is not engineering. There is something more for the fireman to do besides keeping up the steam pressure; there is such a thing as efficiency.

Saving or wasting twenty-five per cent. of the coal consumption of any steam plant depends upon the efficiency of the operating department. If there is a waste the plant will be benefited by a change in the operating management.

It is just about a year ago that the crews in many plants gathered up all the cord wood, packing cases and the chief's desk to keep up steam when the company trucks returned from the coal yard—empty.

Poor power-plant equipment and supplies are handmaids of the devil that encourage profanity and keep men from going to church.

Now that the Fuel Administration no longer can be held responsible, coal consumers await the edicts of the dealers with bated breath.

Increased Costs Make Raise in Price Necessary

Attention is called to an announcement elsewhere in this issue concerning the contemplated increase in subscription price.

The price of "Power" has been held at two dollars for the past eleven years. During this period the cost of paper, engraving and labor involved has practically doubled—in some instances more than doubled; that of paper alone now being over twice the subscription price.

Yet regardless of the ever increasing cost, greater and greater effort has been expended toward making the paper more attractive, making the illustrations tell their story better and in securing material that will be of greatest benefit to the reader in preparing him to hold a bigger place in the engineering world.

The unjustifiable zone system of postal rates has also placed a heavy burden on publishers, amounting in the case of "Power" to approximately the subscription price. But this part of the story has been told before.

What has been the answer? It is to be found in the fact that the majority of magazines, both popular and technical, as well as daily newspapers, have been forced to raise their prices. Some have doubled them.

But "Power" is not passing the whole burden on to the reader. In raising the price to three dollars, it is asking him only to bear a small share. It is even going further than that in permitting present subscribers to renew at the old rate.

We feel confident the reader will appreciate these facts and continue the hearty coöperation and pleasant relations that have marked the past.

Universal raising of wages cannot permanently improve the condition of the workers if it is accompanied by smaller output and shorter hours. There must be greater efficiency and increased production.

The purpose of the grate is to support the fuel bed, but one would not take this to be a fact judging from the appearance of some of the ashpits one sees.

Well, anyway, one gets a lot of consolation in the thought that that stuff he tried to burn last winter helped win the war.

Most chief engineers draw the line when it comes to sociability with their firemen. If the chiefs showed a little more interest in their firemen and in their work, the prospects are that the results would be agreeably astonishing.

All sorts of automatic appliances are used in the power plant, but human intelligence and supervision are required to keep them in proper working order. The man with the automatic brain has not yet been evolved.

Much has been published regarding the care of boilers, engines, turbines and other power-plant apparatus. How about the economizer? Is it not neglected more studiously than any other apparatus in the plant?

Do not make the mistake of assuming that all types of stokers will burn all sizes and grades of coal with equal facility. This is as much of an error as to assume that a crow can fly as fast as a carrier pigeon.

Just what science has done and is doing has been brought to the attention of the average man during the four years of war. The advance made in some branches has been wonderful and astonishing.

Thorough Americanization is the governor that will prevent revolution from wrecking the national machine.

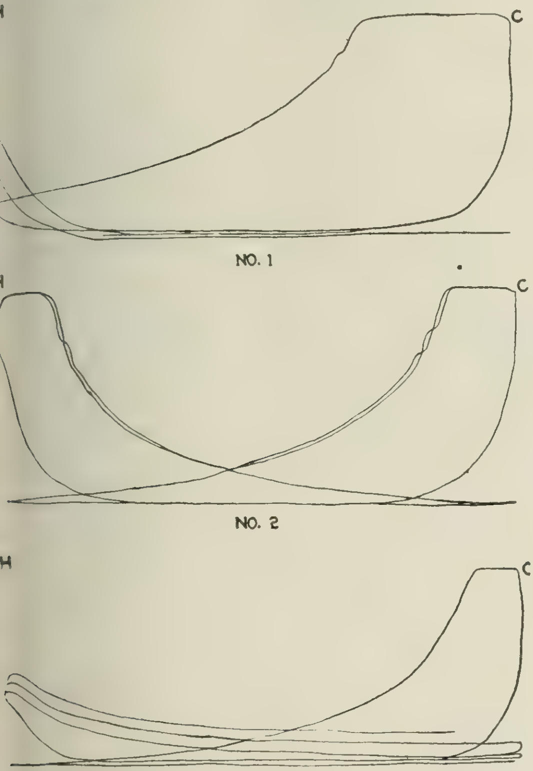
The index to Volume 48 (the last six months of 1918) is ready and will be sent to all whose names are on the index mailing list. Any others who wish will be put on the list. A post card request is sufficient.

CORRESPONDENCE

Odd Indicator Diagrams

Now that the war is over perhaps we can get back discussing some of the engineering troubles we ncountered while keeping the old machines going to roduce supplies for "over there."

The engine from which the diagrams shown were aken is a 24 x 42-in. four-valve with gridiron steam alves and Corliss exhaust valves and operates non-ondensing. The engineer noticed that suddenly the xhaust became very uneven and found that the head-nd steam valve did not open—the latch did not reach ver far enough to engage the block. The engine seemed o be running fairly steady, although taking steam at ne end only, so he took indicator diagram No. 1 hile wondering what had happened. The head end hows only a compression diagram, all the work being one on the crank end; but what had happened to cause his? All bolts on the reach rods seemed tight and othing had slipped, apparently. At last he measured he length of the two dashpot stems and found the ead-end stem was ¼ in. shorter than the one on the rank end. Giving the locknut a "hard try" with his hand, he found it loose, and the stem and dashpot had revolved around and screwed in (shortened) until the latch could not reach the latch block and pick it up. Turning the dashpot around, he unscrewed the stem, thus raising the block until the hook engaged and the valve was again operating. After tightening up the locknut while the engine was still running, he took diagram No. 2. This incident shows what may happen to an engine, and that the difficulty may sometimes be discovered and readjusted in fifteen minutes' time without a stop.



NO. 1

NO. 2

NO. 3

ONLY SLIGHT MISADJUSTMENT DISTORTED DIAGRAMS

On another occasion diagram No. 3 was taken from the same engine. The engine was running full speed and racing slightly. The dashpot on the head end was bouncing and the latch did not engage the block in the ordinary way, and as the hook came over while the valve was open, it forced it shut, but it would spring back from the cushion in the dashpot chamber. The peculiar diagram was probably caused by the reaching of the governor to equalize the load between the two ends of the cylinder; as diagram No. 3 indicates a variation in the steam lines and also leakage of steam into the cylinder after the valve was supposed to be closed. It was found that the packing in the stuffing-box was a trifle tight, and the stem being worn jammed the packing so that the dashpot vacuum could not overcome the friction and excessive compression caused by a choked-up dashpot relief valve. The dashpot relief valve was cleaned out while running and the packing in the stuffing-box loosened until the valve dropped shut freely, and the usual good diagram was produced. R. A. CULTRA.

Cambridge, Mass.

Motor Suddenly Reversed

In regard to John R. Steeska's inquiry in the issue of Jan. 21, page 102, the reason why the motor stopped, reversed and ran in the opposite direction was that the polarity of the armature or field poles was changed, in all probability because a loose rocker-arm allowed the brushes to shift. Just previous to the reversing, the machine should have sparked badly. A case like this happened once in a plant where I was employed.

This also could occur during an electrical storm, as the lightning might injure the motor in such a way as to cause it to reverse. The writer has also known this to occur at the Colorado Smeltery in Butte, Mont.

Butte, Mont. COLIN F. MCGIBBON.

[It is rather difficult to imagine anything that a lightning discharge could do to a motor to cause it to reverse. It is more likely that something happened to cause the machine to reverse simultaneously with the lightning discharge and in cleaning up the effects of the lightning the cause of the motor's reversing was remedied without being found.—Editor.]

Economy in Using Few Pumps

Many buildings are equipped with an unnecessary multiplicity of pumps. In several buildings which I have in mind there are high-pressure drip return pumps and also heating return pumps. In winter they are enabled to shut down the high-pressure drip pumps by connecting the bottom of the high-pressure drip tanks with the heating-system return, and an equalizing pipe is carried from the top of the tank to the heating system above the water line. The water and vapor thus goes to the heating system. The water is handled by the heating return pump and the vapor is utilized in heating the building, the atmospheric vapor pipe being closed off in winter. W. T. MEINZER.

Brooklyn, N. Y.

Generators Would Not Operate in Parallel

Recently, I was called into a plant to investigate the reason why a second-hand compound-wound generator that had been installed a short time previously would not operate in parallel with the other machine in the plant. An investigation indicated the condition shown in Fig. 1.

It will be seen that the equalizer connection on machine No. 2 is connected between the armature and the positive bus. Furthermore, closing the equalizer switch short-circuits the armature of machine No. 1 and connects machine No. 2 across the series field of machine No. 1. Fortunately, the machines were belt-driven or the damage done might have been much more serious than badly burned commutators and brushes, before the circuit-breakers opened and cleared the trouble. On making the equalizer connection between the armature and series field on machine No. 2 and determining that the polarity of the two machines was correct, they were paralleled without any further trouble.

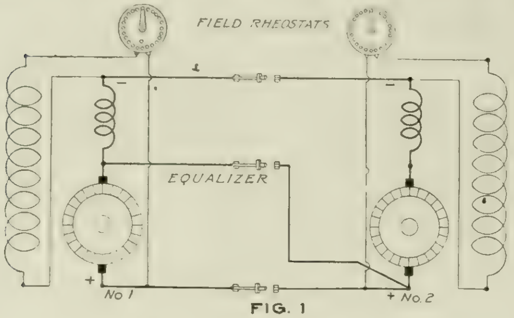


FIG. 1

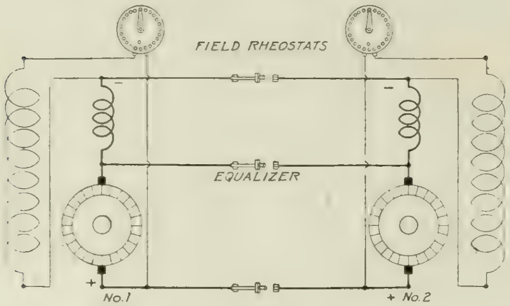


FIG. 2

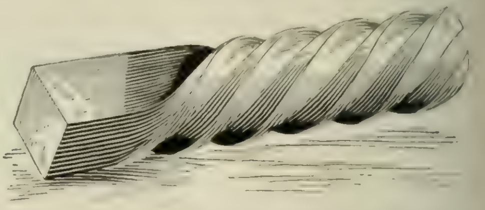
FIGS. 1 AND 2. SHOWS WRONG AND CORRECT CONNECTION OF EQUALIZER

It is evident from the figures that a wrong equalizer connection between two compound-wound generators may cause just as serious a condition as attempting to parallel two machines having opposite polarity—a condition that too much care cannot be exercised to avoid.

Brooklyn, N. Y. E. C. PARHAM.

Backing Out Broken Setscrews

Occasionally little difficult jobs will be encountered, and sometimes they are hurry jobs when time is the controlling element or the lack of suitable tools makes simple tasks difficult. In most cases a little ingenuity will solve the problem. We read of kinks at different times, but the suggestion cannot always be used at once, although the idea may be recalled at the proper time when there is a real need and put into use. Following are two kinks I have used with success:



TOOL FOR BACKING OUT BROKEN SETSCREW

The first case where speed was essential was a problem of backing out a broken setscrew. This was accomplished by drilling a hole in the setscrew and then turning a tool as illustrated into the hole and backing out the screw. This tool has a left-hand thread or spiral and can be made from a piece of square stock, with a slight taper. The thread is formed by heating the metal, holding one end in a vise and twisting the other end clockwise, forming a rough left-hand thread. It can be finished off if necessary with a file.

In the other case poor contact at the brush on the field rheostat of a 400-kw. alternator heated, and the brush was bound so tightly in the holder that it had to be drilled out. This destroyed the brush and a new one was required. The brush was ⅞ in. in diameter and had to fit snugly in the holder. The size of copper nearest to this was 1 in. in diameter. No lathe was available to turn it to the proper diameter and filing was out of the question. The difficulty was overcome by using a set of dies to cut the stock to the proper diameter, by using progressively smaller dies so that the stock was quickly and accurately cut to a proper fit in the brush-holder. JAMES M. PURCELL.

Richmond, Va.

Making Diesel Operators from Steam Engineers

Harte Cooke, in *Power* for Jan. 7, says: "Have you ever heard it asserted that a Ford automobile needed an extraordinarily skilled attendant due to these (high) pressures and temperatures?" No, I don't believe anybody has said that a machine costing less than $500 required such an attendant. However, I would like to ask Mr. Cooke if he would be so imprudent as to employ any f those thousands of jitney drivers such as are found in ne Eastern cities, to operate the fine and expensive en- ines built by his company. I am sure no good execu- ve would be so downright careless and inefficient.

Then Mr. Cooke says: "The ideal engineer to have n charge of a Diesel engine installation is one that is good executive to see that his force actually does the ork which should be done." This is true. But you o not find this kind of men hanging on trees, like ap- les. The kind of men essential in the power plant are ne type that is careful, painstaking and can be trusted, nd I have found such men to be scarce.

Comparing a Ford with a power plant is no compari- on at all. The vital difference is this: A Ford may op for the want of gas or a hundred and one other ings. The driver can give the jitney joy riders their oney back and tell them to catch the next car on the olley line; or if it carries a load of merchandise, he n shove it over in the corner along the fence, go to the earest telephone and call another Ford to come to the escue of a brother in distress. But think of a factory central power plant tolerating such methods! Have ou ever heard anybody say it would be an easy matter shove a balky Diesel in the corner and call up the achine shop to send around another Diesel right away? hat would customers say, if when the lights went out d they called on the phone to find out the trouble, the gineer or the general manager would reply: "Our iesel got hot and blew her head off; but we will have other Diesel some time next week if the railroads n't get snowbound!"

Coming down to brass tacks, let me say this: The men at will make good with Diesel engines are of the same pe that has made good in steam plants; namely, the en that are cautious, careful and take a stitch in time. his is the whole difference between a good power-plant erator and the ordinary man and explains why such man is worth more money than an unskilled laborer. he old adage says, "It isn't the amount you make; it's ne amount you save." And so it is with the engineer: isn't the amount of work you do; there's a lot in king care of things. WALDO WEAVER.

Franklin, Ohio.

igh-Lift Centrifugal Pumps for Irrigation

Although I was interested in the article on "High- ift Centrifugal Pumps for Irrigation," by B. P. Flem- g, on page 138 of the Jan. 28 issue of *Power,* I am not tisfied as to the author's explanation of the decreas- g friction head with increased discharge, in the case f parallel operation of the four pumps. It would, per- aps, be enlightening if we knew where the discharge- nd suction-pressure readings were taken for the case of arallel operation.

Referring to his Table I. it is evident that these umps have a falling head-capacity characteristic; that , the capacity falls off with an increase of head. Turn- g to Table II, it will be seen that the aggregate ca- acity of the four pumps operating singly is 112.28 sec.- ., while the capacity of the four pumps operating in arallel is given as 108.01 sec.-ft., a difference of nearly 000 gal. per min. The logical conclusion is that the umps are operating against a higher head in parallel peration than when operating singly. In other words, the total head for parallel operation must have been more than 88.5 feet.

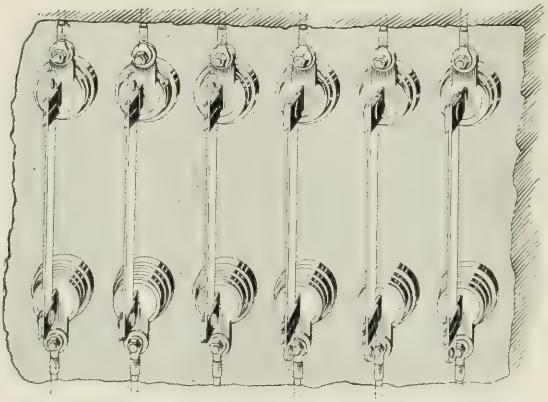
It is hardly reasonable to assume that the improved flow conditions more than offset the increased friction head, when the discharge is quadrupled. As a matter of fact, there is a greater probability of there being heavy swirls and eddies in the manifold with four pumps going than with one only, due to the four converging streams.

I am inclined to think that a velocity or friction head has been overlooked in the case of parallel operation, and this would account for the lower pump efficiency in this case. W. F. BRYE.

Patterson, Calif.

Installing Disconnecting Switches

When installing the disconnecting switches in one of our substations, it was found necessary to mount them on the ceiling, for the incoming lines. As the switches for the different circuits were installed so that they all pointed in the same direction, it was somewhat difficult to identify the individual switches of each circuit. It occurred two or three times that the operator was about to open a switch on a live circuit when he thought it was on one that was out of service. To overcome the possibility of making such a mistake, the switches on every other circuit were reversed, as indicated in the figure. D. R. HIBBS.



ARRANGEMENT OF DISCONNECTING SWITCHES AFTER CHANGE WAS MADE

Philadelphia, Penn.

Thermos-Bottle Principle Applied to Steam Cylinders

I have operated several compound engines with cylinders or receivers steam-jacketed, and in many instances I found that the jacket steam was shut off as it was considered wasteful to leave it on. In fact, this seems to be common practice, as the radiation losses are considered greater than the benefits derived.

It occurs to me that the principle of the thermos bottle could easily be applied to these cylinders or receivers by plugging the inlets and connecting the drips to the condenser, as these engines nearly always operate condensing. This would be no hardship on the condenser, as very little air could penetrate the jacketing walls. Then if neither air nor cold can penetrate through a vacuum, all the heat delivered by the high-pressure cylinder to the receiver would have to go to the low-pressure cylinders.

I am not in a position at present to try this, but would like to hear from readers of *Power* who may have tried it or opinions regarding its merits.

Somerville, Mass. JOHN COLE.

Discussion on Motor Starting Resistance

In the Dec. 24 issue of *Power*, page 927, Gordon Fox asked for information on the following points regarding my article on "Method for Determining Resistance Used for Starting Various Types of Motors," in the Nov. 19 issue:

1. A justification for the tables and illustrations of the action in the case of two or three motors—typical cases.
2. The reasons for specifying so many more resistance points with manual control than with magnetic control.
3. The tables given apply to shunt motors, 50 per cent. compound motors and series motors. How should this information be applied to standard compound motors with 20 per cent. compounding and 40 per cent. compounding?
4. Some discussion of the comparative resistance for use with series motors with series lock-out control as contrasted with speed-control service would be valuable.
5. The current values at which resistance sections should be cut out with shunt motors are given. Are similar data referring to series motors available?
6. Mention has been made only of the proper ohmic value of accelerator resistors. Information as to desirable current capacities would be valuable.
7. Information as to the proper resistance for series motors subjected to plugging service.
8. Information as to resistors for dynamic braking and for dynamic lowering, as in crane service and armature shunts for slow-down work.

The following are answers to the several questions asked by Mr. Fox as enumerated in the foregoing:

1. If two or more motors of the same size are in multiple and controlled by one resistor, the same constants and multiplier should be used as if only one of the motors were being considered and the only factor that need be changed is the normal resistance. To illustrate, if there are three 25-hp. 230-volt shunt motors to be operated in multiple and the full-load current of each is 93 amperes, the total current will be 3 × 93 = 279 amperes. Therefore, the normal resistance $= \frac{230}{279} = 0.824$, which corresponds to 2.473 ohms in Example I of the original article. Thus, $A_1 = 0.078 \times 0.824 = 0.0643$; $B_1 = 0.0643 \times 1.78 = 0.114$; $C_1 = 0.114 \times 1.78 = 0.203$ ohm. If there are two 230-volt motors connected in series on a 230-volt line, then the resistor would be the same as for one motor. If there are two 250-volt motors in series on 500 volts, then the resistor would be for a motor twice the horsepower rating of one and for 500 volts calculated the same as above.

2. There are usually more points on a manual contro than on a magnetic for two reasons: The first i because it does not cost as much to add points to a manual control; and second, because it is essential to keep the voltage from point to point at a minimum so as to reduce the resultant arcing.

3. Tables II, III and IV in the original article give constants for shunt, 50 per cent. compound, and ful series motors respectively, but not values for other than 50 per cent. compound. To obtain values for any desired compounding, calculate with the aid of Table II and IV the resistor divisions for a shunt motor and also the same number of divisions for a series motor. A compound-motor resistor will have values between these two. By obtaining the difference per division between the shunt- and series-motor resistors and then taking a percentage of these differences corresponding to the percentage of the series turns, such as 20 or 40 per cent., and adding it to the shunt-motor resisto values, the desired results will be obtained.

4. The values of ohms determined by the tables are the maximum values which should be short-circuited out of circuit per step, and Mr. Fox refers to this method as series lock-out acceleration. These same values can be used for speed-control service. If equa increments of speed per division are desired, then divide the divisions into equal ohmic values, but these ohmic values should not be greater than the corresponding values determined by the tables, but they may be as "small" as desired. Usually a compromise between the table values and equal increment values are used.

5. Table VII gives constants for use with direct current shunt motors and wound-rotor induction motors starting centrifugal fans. This information was no given for series motors because series motors are no usually applied to this type of load.

6. The capacities of the resistors used for various services depend upon the kind of resistor unit and upon the severity and frequency of starting. A resistor having an average amount of thermal capacity and a comparatively light and infrequent starting duty should have a continuous current capacity of from 30 to 40 per cent. of the current rating of the motor. If the service is very frequent, the resistor should have a continuous current capacity of from 40 to 60 per cent of the motor rating.

7. Resistors to be used for plugging series motors are dealt with in Example XI, which shows that value obtained from the tables are for accelerating a motor To provide for plugging, another resistor division should be added which contains approximately twice the ohmic value used for accelerating.

8. The question of dynamic-brake resistors for use on crane service cannot be dealt with very well without the exact connection diagram. If Mr. Fox wishes any detailed data on some particular arrangement, I will be glad to correspond with him regarding it.

Schenectady, N. Y. B. W. JONES.

The statement that wastes in the boiler room equa all other plant losses combined may appear to be rather sweeping, but is it? When fuel losses, hot-water losses steam losses and combustion losses are considered, the statement could be made more sweeping in reference to some steam plants.

INQUIRIES OF GENERAL INTEREST

Compressed Air No Assistance to Suction Lift—Would ot compressed air, introduced at the top of a capped well asing, be of assistance in raising water with a pump uction pipe that is let down in the casing? J. H.

The compressed air will simply depress the level of the ater in the casing without any effect of raising the level f the water in the pump suction pipe, for it would connue to depend on the head and flow of the ground water. f the air pressure were sufficient to depress the water own to the foot of the casing, it would prevent any water rom entering the casing.

Knock in Low-Pressure Cylinder with Light Load—What ould cause a knock to set up in the low-pressure cylinder f a compound condensing engine whenever the load is educed and the vacuum goes from 26 in. to about 28 in.? R. H.

If the knock with the lighter load is heard like a slaping noise, as though the exhaust valves are driven from heir seats, it may be attributed to expanding the steam elow the pressure of the exhaust. The trouble would be emedied by increasing the relative length of cutoff of the w-pressure cylinder. But if the knock is in the nature of a ound, such as might be due to slack connecting-rod brasses, probably would be due to insufficient compression of the xhaust for good cushioning effect. To obtain the same mount of compression and cushioning on the exhaust with e lighter load and higher vacuum, the lower pressure f the exhaust will require the exhaust valves to be set they will be closed earlier in the stroke.

Meaning of "Pound of Steam"—What is meant by a ound of steam? Is it not a pound of water evaporated nto a pound of steam? W. D.

The expression "a pound of steam" means mass of the ubstance whose weight is one pound avoirdupois, just as gnified by the terms a "pound of feathers" or a "pound f lead." When a pound of water is evaporated, it is onverted into a pound of steam, and when the steam is ondensed it is converted back to the same weight of ater; consequently, the weight of steam is commonly xpressed in pounds weight of water required for generaon of the steam, or pounds of water resulting from its ondensation. When speaking with reference to the condion of the steam, the expression "pounds of steam," as ost commonly used, refers to the pressure exerted per quare inch above the atmosphere, or "gage pressure," but hen quantity is referred to, the expression "pounds of eam" refers to the weight of steam under consideration.

Selection of Initial Pressure—In operating a 150-hp. oncondensing Corliss engine my superintendent claims ore steam is used at 80 lb. boiler pressure than there ould be for 100 lb. pressure. I believe there is less steam sed at 80 lb. pressure. Which is right? A. E. S.

Analysis of indicator diagrams taken of the average load robably would reveal which is right. If the load is such hat for steam at 100 lb. pressure the required point of utoff results in expansion to not less than about 3 lb. bove the pressure of the exhaust, then it would be more conomical to supply the engine with steam at 100 lb. ressure. Otherwise the lower initial pressure would be ore economical, for although there would not be as much ork of expansion realized from the later cutoff, there ould be a higher terminal pressure and the less range of ylinder temperature would result in less loss of heat from he cooling effect of the exhaust than in case of higher itial pressure and a lower terminal pressure.

Use of Air Chambers with Pumps—Why are some pumps ade with air chambers while others are not? C. R. K.

The purpose of an air chamber is to provide an elastic element for taking up the shocks and irregularities and for inducing a uniformity of flow in the pipe line. In single and in duplex single-acting pumps, although the reversal may be instantaneous, there is of necessity a momentary stoppage that is attended by an interruption of the flow and, for smooth running, an air chamber is necessary to take up some of the water during the stroke and replenish it during the pause. An air chamber should be used with crank and flywheel pumps of any type on account of the rapid fluctuations of piston speed, but they may be dispensed with in duplex double-acting low service pumps, in small duplex pumps for general service and in small slow-running pumps such as deep-well bucket pumps and for use with centrifugal and ordinary types of rotary pumps where the flow is nearly continuous.

A. C. Voltage on Rotary Converter—If the direct-current voltage of a six-phase rotary converter is 250 volts, what must the alternating-current voltage be at the collector rings? C. A. R.

The value of the voltage at the collector rings of a six-phase rotary converter to give 250 volts at the commutator will depend upon how the converter is connected to the transformers. If in double delta, the voltage at the collector rings will be the direct-current voltage times 0.612, or in this case 250 × 0.612 = 153 volts. If a diametrical connection is used, then the alternating-current volts equal the direct-current volts times 0.707 or 250 × 0.707 = 176. A third arrangement is the six-phase connection in which the alternating-current volts is equal to the direct-current volts times 0.354; in this problem 250 × 0.354 = 88 volts. These voltages are theoretical values; in practice the voltages will probably be about 5 to 10 volts higher. The connection generally used is the diametrical arrangement as this allows employing the highest alternating-current voltage at the collector rings.

Kilovolt-Amperes and Power Factor—I am in charge of a 600-kv.-a. alternating-current generator and would like to know the meaning of kilovolt-ampere and how horsepower is figured from it; also the meaning of power factor. M. J.

The power (watts) delivered by a direct-current generator is equal to the volts times amperes. In an alternating-current generator this is true only when the current is in step with the voltage, consequently the product of the volts and amperes, with respect to power, may mean anything from zero to the value of their product; therefore kilovolt-amperes (kv.-a.) has been adopted as a unit for rating alternating-current generators, synchronous motors, synchronous condensers and transformers. For a single-phase circuit the kv.-a. $= \frac{EI}{1000}$; in a balanced two-phase circuit, kv.-a. $= \frac{2EI}{1000}$; and on a balanced three-phase circuit kv.-a. $= \frac{1\,732EI}{1000}$, where E equals the voltmeter reading and I equals the ammeter reading. The wattmeter will give the load in kilowatts and this divided by kilovolt-amperes gives the power factor; that is, power factor $= \frac{\text{kilowatts}}{\text{kilovolt-amperes}}$; from which kilovolt-amperes $= \frac{\text{kilowatts}}{\text{power factor}}$ and kilowatts = kilovolt-amperes × power factor. Horsepower $\frac{\text{kilowatts} \times 1000}{746}$ or $\frac{\text{kilovolt-amperes} \times \text{power factor} \times 1000}{746}$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Industrial Unrest*

The industrial problem which confronts not only our own country but all civilized nations, is probably the most vital one with which we as citizens have to deal. Extreme radicalism, either on the part of Government, labor or capital, will not heal the wounds caused by the many suspicions, misunderstandings and even animosities that are the outcome of the long struggle which the world has been making to keep the pendulum of human rights at the equity mark, halfway between overbearing capitalistic autocracy on the one hand and the anarchistic elements on the other.

Neither is it proper to throw all the blame for the present unfortunate industrial conditions on capital or all on labor or all on government. There are many who have decided ideas on this subject, but it must be constantly remembered that the interested parties in this triangular dispute are labor, capital and the government.

Throughout all allied countries workers of all kinds recently rose in defense of the ideals of liberty, democracy and world peace, and they counted no price too great for their protection; yet, at the same time, there is grave danger that the benefits of our great victory for these ideals may be wholly nullified by the widespread dissensions and misunderstandings in the industrial world.

To capital should be pointed out that the laborer is worthy of his hire, that right working conditions and surroundings should be safeguarded to him, that more and more the profits and benefits of successful business must be equitably divided among those who produce the profits which it has come to be realized now means both the employed and the employer.

It must be pointed out to capital that labor can be no longer successfully exploited, that fair dealing is due to the workman by his employer, just as fair dealing is expected by the employer from his workmen.

To labor it must be pointed out by those in authority at the head of our Federal and State Governments that the interests of capital and labor are in the end identical—that the man who rows the boat, if he scuttles it with the idea of giving the man who steers it an unpleasant cold bath, will get the same bath himself.

To labor it must be pointed out that Anarchy and I. W. W.ism and Bolshevism, all more or less synonymous, are as contrary to the high ideals of American citizenship as anything could well be. To labor must be pointed out that we have just won a victory of right against might and that the temporary ability of a trade-union organization to secure unjustifiable and uneconomic hours of work or dollars of wages is but the Prussian idea of might over right; that there must be reasonableness in all things, even the demand of labor, and that labor must be constantly awake to the dangers which confront it, not from outside in the form of the employer so much as from within in the shape of the alien agitator, the unamericanized anarchist or the pro-German Bolshevist who in fanatical fury would pull the industrial structure down upon their own heads.

No department of the United States Government, whether it bear the name of "Labor Department" or "Capital Department," should ever approach the problems pertaining to that department from one side only. A labor department that merely represents labor does not make for industrial harmony and peace; neither does class legislation which has for its goal benefits which accrue to the employer or capital only, make for industrial peace. On the contrary, they are more likely to bring about an industrial catastrophe that may well wreck the hopes and aspirations of all citizens of the United States, whether they be employers or employees.

There is the great question of restriction of immigration before the Congress of the United States today. It may well be that that measure supported strongly by labor is part of a plan to create a corner in the supply of labor. If so, to enact it would be to perpetrate a great economic wrong on a country whose very greatness is the result of immigration of years to its shores.

Legislators must be taught, and I use that word advisedly, that one-sided legislation is one of the worst things that can come out of a Congress.

If the employer profiteers, it is well that the politician and statesman should cry out against it from the housetops. If labor profiteers, it is equally proper that statesmen must utter their open condemnation of such a proceeding.

I. W. W.ism, Bolshevism, hurling of monkey wrenches into the machinery of social order, both at home and abroad, must stop, and someone with a voice loud enough to be heard must utter the warning.

In closing I want to say as an American citizen, proud of my country, that while America may, and undoubtedly does, need readjustment to the new state of things, it does not need revolutionary reconstruction, and it is the patriotic duty of every publisher and editor to see that, above all else, reconstruction is not attempted by alien agitators, Unamericanized socialists, and many other pro-German elements, now more or less carelessly classified as Bolshevists.

Horsepower Developed from Water in Canada

A census of the developed water power in the Dominion just completed by the Dominion Water-Power Branch of the Department of the Interior, in coöperation with the Dominion Census Bureau, discloses exceptionally interesting figures. The water-power resources of Canada, with their strategic locations adjacent to practically every industrial center, constitute one of the greatest assets, and it is satisfactory to note that the economic advantages accruing from utilization of these powers for industrial purposes is being fully realized in practice.

The accompanying table analyzes the installed turbine or waterwheel capacity of the Dominion by provinces, and by use of power. The returns indicate a total developed water-power capacity of 2,305,310 hp. The figure is several hundred thousand in excess of any estimate previously published and indicates that Canada's utilization of hydro power is even more marked than had been realized.

Of the total water power developed, 1,727,471 hp. is installed in central electric stations, that is to say, in stations developing electrical energy for distribution and sale; 352,214 hp. is installed in plants owned and operated by pulp and paper companies, and 225,625 hp. is installed in other miscellaneous manufacturing and general industrial establishments. The foregoing figure for pulp and paper companies does not, however, represent the total amount of water power used in that industry; upward of 100,000 hydro-electric horsepower in addition, is purchased by pulp and paper companies from central electric stations, making the total hydro power utilized in pulp and paper industry some 450,000 hp. If this 100,000 hp. is added to Column 2, it should be subtracted from Column 1 to maintain the correct tabular totals.

Returning to the central electric station total of 1,727,471 hp., it is of interest to record that the central stations already constructed throughout the Dominion are designed for a machine installation of 530,000 hp. in addition to the machinery now installed. Of this amount the installation of 270,000 hp. is at the present time under contemplation in various parts of the Dominion. These figures do not include the 300,000-hp. Queenstown plant which the Hydraulic Power Commission of Ontario has under construction at Niagara.

Column 5 of the table discloses interesting figures respecting the hydro-power development in the various provinces on a per capita basis. In the Yukon the hydro power developed per thousand population totals 1574 hp., in British Columbia 506 hp., in Quebec 376 hp., in Ontario 359 hp., and in Manitoba 133 hp. The other provinces average smaller figures. The ratio for the entire Dominion averages 276 hp. developed per thousand population. The availability of hydro power, the distribution, density and occupation of the population have a very direct bearing on the amount of power developed.

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*Excerpt from an address by Roger Allen before the New York Business Papers Association.

The exceptionally high ratio in the Yukon is accounted for by extensive use of hydro power in the mining industry in conjunction with the comparatively small population.

The per capita figures of hydro power developed for the Dominion, when compared with similar figures for other countries, are indicative of the advanced position which this country takes both in the extent and in the utilization of its water-power resources. Norway and possibly Sweden are the only countries where the per capita utilization of water power exceeds that of Canada. The most recent figures available for the United States would indicate a utilization of less than 100 hydraulic horsepower per thousand population, as compared with 276 per thousand in Canada. The fundamental reason underlying the extensive use of water power in Canada is the fact that practically every commercial center from coast to coast, excepting only a few in the middle Prairie Provinces, have abundance of water power available, not only for present needs, but for all anticipated requirements.

DISTRIBUTION OF DEVELOPED WATER POWER IN CANADA BY PROVINCES AND BY USE OF POWER, JAN. 1, 1919

Province	Central Electric Stations Horsepower	Pulp and Paper, Horsepower	Other Industries, Horsepower	Total Horsepower	Horsepower per 1000 Population
Yukon....	10,000	...	3,392	13,392	1,574
B. C......	221,625	46,450	44,348	312,423	506
Alta......	32,580	......	300	32,880	63
Sask......	......	......	......	......	......
Man......	64,100	......	12,072	76,172	133
Ont.......	791,163	133,952	59,945	985,060	359
Que......	597,601	155,512	89,648	842,761	376
N. B......	6,878	2,800	5,191	14,869	41
N. S......	3,354	13,500	9,170	26,024	51
P. E. Id...	170	......	1,559	1,729	19
Total...	1,727,471	352,214	225,625	2,305,310	276

Iron and Steel Electrical Engineers Discuss High-Voltage Fuses

The Pittsburgh Section of the Iron and Steel Electrical Engineers held its regular monthly meeting in the roof garden of the Hotel Chatham, Pittsburgh, Penn., Saturday evening, Feb. 15, 1919. The meeting was preceded by an informal dinner at 6:30, which approximately 100 members and guests attended.

The meeting was called to order at 8 p.m. President D. M. Pettie, after a few brief remarks regarding the work of the society, introduced Alfred Alsaker, who presented a paper on "Outdoor Substation Practice and the Use of Carbon Tetrachloride Fuses." In his introductory talk Mr. Alsaker pointed out how the problem of supplying large communities with electrical power from large economical power plants was solved by the introduction of high-voltage alternating current, this power being transmitted to economically located substations in various parts of the community and distributed in various forms from these indoor substations. This also made possible the development of our large water-power resources. However, the equipment used for large cities was not suitable for small communities, on account of the high cost of substations, and it remained for the development of the outdoor substation to solve the problem of serving small towns from large high-voltage systems. In these stations air-break type switches in general are used and protection is obtained by the use of various types of high-voltage fuses. The speaker described three types of the fuses—the horn-gap type, the inclosed type and the carbon-tetrachloride type. The last-named type is also an inclosed fuse of special construction using a short piece of fuse attached to a spiral spring under tension in a tube filled with carbon tetrachloride. When the fuse blows, the spring recoils into the opposite end of the tube, introducing a long break in the circuit, and the carbon tetrachloride rushes in and quenches the arc. It was brought out that the carbon-tetchrachloride fuse could open a circuit in 0.013 part of a second.

After the presentation of his paper Mr. Alsaker showed a large number of lantern slides of various types of outdoor substations, and then followed a discussion, in which a large number took part. During this discussion it was brought out that carbon-tetrachloride fuses had ruptured a circuit at a maximum instantaneous load, as shown by an oscillograph, of 132,000 kv.-a. at 110,000 volts, and that automatic air-break switches had ruptured 90,000 kv.-a. when located on the end of a 40-mile, 44,000-volt transmission line. The meeting was closed by Vice President B. W. Gillson.

The next meeting will be held by the Philadelphia Section at the Engineers' Club, Saturday evening, Mar. 1, 1919. A paper, "The Substitution of Electric for Hydraulic Power in Steel Mills," will be presented by R. B. Gerhart. A meeting of the Cleveland Section will also be held on Mar. 1 at the Electric League Rooms, Hotel Statler, Cleveland, Ohio. "Telephones" is the subject to be discussed at this meeting.

Standardization of Boiler Blowoff Valves

At a meeting at the Engineering Societies Building, New York City, Thursday, Feb. 13, a number of representative blowoff-valve manufacturers gathered for the purpose of considering matters of importance regarding the manufacture of boiler blowoff valves, especially the standardization of flanges and the elimination of unnecessary sizes and varieties of valves.

It was the sense of the meeting that there was no engineering demand for freak designs, which are frequently asked for by some consulting engineers and others, such as flanges at one end and screwed connections at the other, steel body castings, special markings, etc., all of which make it necessary for the manufacturer to carry a large number of patterns. Although special valves cost more to manufacture, the purchaser expects to obtain them at the same price that he pays for a standard article. Again, a certain size of blowoff valve may be made standard with screwed end connections, but flanged valves must be carried to meet the demands for such when they are made.

After considerable discussion the following recommendations were made, to be submitted for a referendum to all manufacturers of blowoff valves who were not represented at the meeting. If the recommendations as made do not meet the views of the manufacturers as a whole, they will be modified or enlarged until all can agree on a common basis.

The first recommendation adopted was that not smaller than 1-in. and not larger than 2½-in. boiler bottom boiler-blowoff valves be manufactured, these sizes being those recommended by the A. S. M. E. Boiler Code, the intermediate sizes to be 1½- and 2-in. only.

Regarding connections, the recommendation adopted for blowoff valves for use on power boilers operating with pressures up to 250 lb. was that such valves be made extra-heavy pattern only, and that the 1-in. sizes have screwed connection, the 1½- and 2-in. sizes screwed or flanged, and the 2½-in. size flanged only. It was, however, recommended that the 1½- and 2-in. sizes be preferred flanged.

A final recommendation was that the manufacturers should reduce the variety of styles to the smallest number of types possible, in the interest of conservation and economy.

It is proposed that as soon as all the blowoff-valve manufacturers agree as to the types and sizes that good engineering requires, their recommendations be submitted to the Industry Committee on Valves and Pipe Fittings, which has succeeded the War Service Committee, for approval and adoption. This will be necessary if harmony in fittings is to prevail.

In the boiler and engine rooms care should be exercised to see that the passageways are kept clear, and that fire tools, barrows and other obstructions are kept in their proper places. Fuel and ashes should also be kept within restricted limits.

Where a safety valve blows off across the top of a boiler the outlet should be so extended that the steam will be discharged vertically, above body level if practicable.

Water-Power Development in France

On Monday evening, Feb. 10, 1919, in the auditorium of the Engineering Societies' Building, New York City, at a joint meeting of the American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Society of Civil Engineers and the American Institute of Mining Engineers, the delegation of American engineers to the French Engineering Congress, recently held in Paris, made a preliminary report on the work of the congress. Lewis B. Stillwell was chairman of the committee appointed by the delegation to represent it at the Paris Congress, on water-power development. In making his report Mr. Stillwell said in part regarding water-power development in France:

There are three important water-power districts in France: The region of the Alps in southeastern France, drained by the Rhone and its tributaries; the northern slopes of the Pyrenees; and the elevated region in the south-central part of France, drained for the most part by streams flowing northward into the Loire and westward into the Garonne. Of these the region of the Alps is by far the most important. It is estimated that the total hydraulic power available for commercial development in France is approximately 4,500,000 hp. Hydro-electric plants thus far installed aggregate a capacity of approximately 1,000,000 hp., of which about 800,000 hp. are in the watershed of the Rhone and its tributaries.

In the valley of the Romanche the Société Electrothermique Keller-Leux is installing a power plant which will utilize in one step a fall of 1100 m. (3608 ft.) The diameter of the pipe is 18 in. (45.7 cm.). Another development which particularly interested the committee is the manufacture of iron pipe by electrolytic deposit of iron upon revolving cylinders.

At the beginning of the war there were in Dauphine 29 hydro-electric stations, producing an aggregate of 170,000 hp. At the end of June, 1918, 40 plants were in operation, producing approximately 220,000 hp. It will be noted that, notwithstanding the extreme urgency of war conditions, the increase is only 50,000 hp., although far larger amounts of undeveloped power are available in this region and if developed would have been of the utmost value to France.

The time available to the delegation did not permit a visit to the region of the Pyrenees. The impetus toward water-power development has been felt in this region, and several important plants are now in operation, including one of approximately 20,000 hp. and another of 32,000 hp. The committee was informed also that two projects are under way in that region which will employ for transmission purposes a potential of 120,000 volts. The highest hitherto used in France is 60,000 volts.

The third water-power district is that of the Massif of the south-central part of France. This region is extensive in area and there are a number of streams of high aggregate fall, but these streams are not large and the potential power possibilities of the region are by no means comparable to those of the Rhone.

In the years immediately preceding the great war the annual consumption of coal in France was something over 60,000,000 tons. Of this amount approximately one-third was imported. The average price then was from $5 to $6 per ton. It is probable that in the future the price will be materially higher, probably about $8 per ton. It is obvious, therefore, that France should develop her water power as rapidly as may be practicable.

The Engineering Congress at its session in March last adopted recommendations looking to the standardization of frequency and voltage. It was recommended that 50 cycles per second be adopted as the standard frequency and that the use of 25 cycles per second be permitted in special cases.

Operator Saves Turbine

At the station of the New Bedford Gas and Edison Light Co., an operator, by his coolness, probably prevented material damage to a 15,000-kw. turbine by tripping the throttle and staying with the machine until it had stopped, after a piece of the last, or ninth, wheel had let go and blown through the low-pressure casing. The machine, which at the date of the accident, Feb. 6, had been in service about a year and a half, was of the single-cylinder horizontal type, the last wheel being about 100 in. diameter and running at a relatively low peripheral speed—460 ft. per sec. The machine had been synchronized, and when the load reached about 200 kw. the accident occurred.

An investigation is now being made into the causes of the failure, and the finding will be awaited with interest by engineers in general.

Cutting boilers in and out, forcing them to operate at too high or allowing them to run at too low rate of steaming, attempting to change the rate of combustion too rapidly and failure to equalize the combustion rate as much as possible on all the boiler units being fired, all add to the waste of fuel.

Youth is the expanding, affirmative period, early manhood the experience period, middle age the period of balance, slower to acquire but safer to advise; subsequently occurs the conservative period, making gains secure, when a novelty must be startling to arouse interest, later still nothing excites any reflex action.

Steam-pipe loss is brought about partly by convection, but mainly by radiation. It is also greater when steam is flowing through the pipe, as when the engine is running, than when there is no flow. Moisture in steam and its deposition on the pipe surface assist in the transfer of heat to the pipe.

New Publications

RESULTS OF MUNICIPAL ELECTRIC LIGHTING IN MASSACHUSETTS. By Edmond Earle Lincoln, Instructor in Economics, Harvard University. Published by Houghton Mifflin Co., Boston and New York. Cloth; 481 pages, 5½ x 8 in. 16 charts; numerous statistical tables. Price, $3.

The author of this book has made an exhaustive study of the municipal electric-lighting situation in the State of Massachusetts with a view to determining how it compares with private enterprise in the same field. To that end he has collected and analyzed a vast amount of data concerning legal regulations and restrictions, the physical equipment of stations, the financial statistics of generating and purchasing plants and their local backgrounds. He compares public business with private business at its worst in the state and reaches the following interesting conclusions: That municipal electric-lighting plants, while they have not been failures, have not shown conspicuous success; that they perform services which might have been rendered equally well, if not better, by private enterprise; that under existing regulations in Massachusetts there is no reason why a municipality should invest in an electric light plant, certainly not a generating plant; that the public can hope for better service from plants under group control, properly regulated, than from those independently owned and operated; and finally, that municipal plants should be required, by law if necessary, to be conducted exactly as if they were commercial enterprises, so that the public may understand whether they are gaining or losing. There probably will be some who will disagree with the author's findings, but none will question his intention to analyze the problem thoroughly and impartially.

MAN TO MAN; the Story of Industrial Democracy. By John Leitch. Published by D. C. Forbes Co., 299 Broadway, New York City. Cloth; 250 pp.; 5 x 7½ in. Price $2.

The author believes that the present condition of industrial unrest, due to the changing status of industry and the increased cost of living, demands imperative remedial action. He explains that industrial democracy has been evolved through years of experiment based on the fundamental principle of justice between employer and employee. Its machinery, which is modeled after the legislative machinery of our Federal Government, provides the means of communication by which the opposed ends of the industrial organization may get together, learn each other's trials and limitations and cease to be opposed. Citations of the workings of systems as installed in industrial establishments occupy four chapters of the book. The author shows that in these cases the system has had the effect of increasing production and profit, while at the same time it has increased the financial returns of the employee, eliminated the spirit of unrest and substituted a feeling of mutual confidence.

STORING. By H. B. Twyford. Published by D. Van Nostrand Co., New York City. 1918. Cloth; 6 x 9 in.; 21 pages; 96 illustrations. Price, $3.50.

This book treats of storing, its economic aspects and proper methods in manufacturing plants. The author looks upon the question of "To store or not to store" as one of great economic importance to manufacturers and one that must be settled, in many cases, on a more scientific basis. The book is divided into 12 chapters, namely: General Considerations; Economic Questions Connected with Storing (two chapters); Specifications, Definitions and Standardization; Location and Equipment of Storeroom; Appliances for Use in Storeroom; Manual Operation; Clerical Work—Inventories; The Stores Department; Receiving Material; Inspecting and Placing Material in Storeroom; and Deliveries from Storeroom. The subject is considered from e practical side as well as from the theo-tical. The construction of various types f bins and racks and their location in orerooms are not only described, but a umber of illustrations are given which ake the chapter on this subject of excep-onal value. The chapters on appliances nd manual operation, give numerous ap-liances and equipments, including trucks, cales, counting machines, conveyors, tote oxes, etc., for handling both raw and anufactured materials. Numerous forms re given in Chapters VIII to XII for aking out inventories and keeping record materials received, stored or delivered, tc. This work should prove of valuable ssistance to all those who have manufac-uring, storage and handling problems to olve.

PRACTICAL HINTS ON RUNNING A GAS ENGINE

The United States Department of Agri-ulture has issued Farmers' Bulletin 1013, ith the foregoing title, its purpose being assist in conserving farm labor by of-n, practical help to operators of gas ngines. It mentions the more common uses of trouble with gas engines and uggests methods of locating quickly the ason for the failure of the engine to perate as it should. Directions are given r testing the ignition system and the fuel stem and there is an extended discussion f the problem of starting in cold weather. t the end of the bulletin is a chart for iagnosing engine troubles systematically. he sixteen pages contained in this publi-ation are full of information clearly written nd easy to understand and apply.

CENTRAL STATION HEATING

This bulletin is Technical Paper 191 of e Bureau of Mines and deals with the onomic features of central-station heat-ng with reference to community service. points out that at best only about 15 er cent. of the heat of the fuel can be con-erted into electrical energy and that 6 er cent. is common, so that great gain is ossible by combining steam power plants nd central-station systems. It discusses e question of rates and costs of such eating and makes the following recom-endations: It would appear advantageous select plant locations more favorable to e district to be served; adopt more per-anent construction materials and improved esigns; submerge the power load entirely t all times during the heating season; put ll consumers on meter rates with an quitable demand charge; run compound ngines, or exhaust the turbines tandem to imple engines during the summer months.

Obituary

Frederick L. Hickock, president of the eliance Gauge Column Co., of Cleveland, hio, died of pneumonia at his residence East Cleveland on Feb. 16, after a week's lness. He was 36 years of age. He was onnected with the Ingersoll Milling Ma-hine Co., Rockford, Ill., for five years, and as associate editor of "Machinery" for our years. He was a member of the Uni-ersity and Advertising clubs and of the indermere Masonic Lodge. He is sur-ived by his widow and three daughters.

Personals

Theodore R. Hermanson, formerly of the arrison (N. J.) works of the Worthington achinery Corp., is now works manager of he Epping-Carpenter Pump Co., of Pitts-urgh, Penn.

Wyan Eaton, who until recently was en-ineer in charge of the rolling mill work f the Mesta Machine Co. has been ap-ointed chief engineer of Freyn, Brassert Co., Engineers, Peoples Gas Building, hicago.

Lewis S. Maxfield, formerly mechanical ngineer for the Carver & Nate Co., engi-eering contractors, has resigned to become ssistant to the secretary of the Heating nd Piping Contractors National Associa-ion, 29 West 39tn St., New York City.

Alfred H. Bartsch, formerly advertising anager of the Bosch Magneto Co., and or the last two years merchandising and dvertising counsel to many large automo-ive industrial firms in Philadelphia, has een appointed general sales and adver-ising manager of the American Bosch Magneto Corp.

Charles H. Herter, for many years research engineer with the De La Vergne Machine Co., New York, and well known in ice and refrigerating circles, has entered the employ of Chas. A. Schieren Co., 30 Ferry St., New York City. Mr. Herter will specialize on belting calculations in Schieren's engineering service department.

James N. Hatch, consulting engineer, Chicago, has formed an association with Henry C. Eckland, architect, and formerly connected with Eckland, Fugard & Knapp. The new firm will be known as Henry C. Eckland & Co., architects and engineers. Mr. Hatch, however, will continue his consulting practice of public utility and industrial engineering as heretofore.

Col. C. H. Crawford, of Philadelphia, has been elected director of the American Association of Engineers to succeed T. M. Chapman, deceased. Colonel Crawford served in the purchase, storage and traffic division of the general staff of the War Department during the war, and has recently taken employment with the Baldwin Locomotive Works at Philadelphia. He has been interested for a number of years in the unity of the engineering profession, and was an active member on the committee on coöperation, representing the Engineering Association of Nashville.

Engineering Affairs

The Association of Iron and Steel Electrical Engineers, Philadelphia Section, will hold a joint meeting with the American Institute of Electrical Engineers on Mar. 1 Dr. W. S. Franklin, of the Massachusetts Institute of Technology, will lecture.

The Eccentric Association of Firemen, No. 56, I. B. of S. F., held its twenty-fourth annual entertainment and ball on Feb. 11, at the Star Casino, New York City. There was a good vaudeville show and dancing was a feature of entertainment.

Miscellaneous News

The Engineering Experiment Station, University of Illinois, at Urbana, maintains fourteen research graduate assistantships. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $500 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools. Nominations to these positions must be received by the director of the Station each year, not later than Mar. 1. Additional information may be obtained by addressing the director of the Station.

The Fourth Lyon Fair will be held in Lyon, France, Mar. 1 to 15. The fair is under the patronage of the President of France and of the Minister of Commerce and Industry. The Organizing Committee of the fair is under the presidency of Senator Edouard Herriot, mayor of Lyon. The United States Department of State and Department of Commerce have endorsed the fair. On account of the apparent interest manifested by American manufacturers and exporters the Fair officials have now arranged to place additional space at the disposal of American exhibitors. The Committee of the Fair has sent a special representative to the United States to aid American firms and individuals that may care to exhibit their samples.

The Professional and Special Section of the United States Employment Service, formerly located at 299 South La Salle St., has removed to new and more extensive quarters at 63 East Adams St., Chicago. This section, formerly known as the Division of Engineering, will enlarge its service to include all kinds of professional and technical men and women. During the war this branch of employment did notable work in placing engineers and technical men in various branches of the war and the Government. Now its activities will be directed toward reconstruction and peace needs. Engineers and professional men and women desiring the services of the Professional Section, are requested to write to the above address for registration blanks. In order to secure quick service, applicants are advised to communicate with the branch of the Professional Service which has jurisdiction over their zone district. People living in Illinois, Indiana, Iowa and surrounding territory should register with the Chicago office. No charge is made for this service.

Business Items

The Wisconsin River Power Co. has moved its general offices from 73 West Adams St., Chicago, to 16 Carroll St., Madison, Wis.

Badenhausen Co. announces the opening of its Pittsburgh office at 5030 Jenkins Arcade, with A. D. Neeld, Jr., in charge. This office will cover sales in Ohio, West Virginia and western Pennsylvania.

The Barber-Greene Co., of Aurora, Ill., announces the following additions to its staff: W. A. Buell, formerly conveyor engineer of the Goodyear Tire and Rubber Co., sales engineer; H. W. Cudding, formerly general auditor of the Lyon Metallic Manufacturing Co., auditor.

The H. W. Johns-Manville Co. has this year distributed to all its salaried employees an extra compensation of 20 per cent. on the salaries paid them during 1918. It has been the custom of this company for some years past to recognize the faithful service of its employees in this manner.

The De Ved Kissick Co., Inc., New York City, announces that it has added to its line of power-plant fuel and labor-saving specialties the vapor and vacuum heating systems of the Illinois Engineering Co. for the New York territory. This new department will be under the supervision of A. T. Browne, who has been active in the heating and ventilating field for the past eight years.

Edward R. Ladew Co., of Glen Cove, New York, announces some changes in its Southern organization, as follows: O. S. Horton has been appointed manager of the Southern branch, with headquarters at Charlotte, N. C., and territory covering all states south of Maryland, West Virginia, Kentucky and Arkansas, west to Texas; Walter Carr, formerly of the New York office, is assistant branch manager.

Trade Catalogs

Sidney Open-Back Inclinable Presses. Sidney Power Press Co., Sidney, Ohio. Catalog. Pp. 8; 8½ x 11 in. This illustrates and describes the types of flywheel press manufactured by this company.

Ball and Roller Bearings. Gwilliam Co., 253 West 58th St., New York. Catalog. Pp. 18; 6 x 9 in. This illustrated booklet gives the dimensions and specifications of all types of ball and roller bearings.

The Service Engineering Co., 25 Church St., New York, has issued a four-page circular telling who the company is, what it does and how it does it. Interested parties may obtain this circular by writing for it.

N. G. E. A. 1918 Blue Book. Issued by the National Gas Engine Association, Lakemont, N. Y. This is a classified directory of the members of the Association. It contains a copy of the constitution and by-laws.

Zelnicker's Bulletin No. 259. Walter A. Zelnicker Supply Co., St. Louis, Mo. Catalog. Pp. 16; 3¾ x 8¼ in. Giving specifications of all kinds of tanks. Interested parties may obtain a copy by writing to the Walter A. Zelnicker Supply Co., St. Louis, Mo.

The De Laval Steam Turbine Co., of Trenton, N. J., has issued a 32-page illustrated catalog (Bulletin M) entitled "Geared Marine Steam Turbines," describing standardized geared turbine units for marine service, details of construction of turbines and gears and also various turbine-driven auxiliaries, including lighting sets, circulating pumps, boiler feeders, etc.

The Heine Safety Boiler Co., St. Louis, Mo., has just completed the printing of the latest edition of its "Boiler Logic," an 86-page treatise on steam boilers, which covers the following topics: Some fundamental consideration of boiler design; practical baffling of water tube boilers; Heine boilers for different fuels; overloads; the boiler as a pressure vessel, and details of construction, Heine boilers.

The Crescent Principle of Belt Joining. Crescent Belt Fastener Co., 381 Fourth Ave., New York. A four-page circular which summarizes the reasons why people buy Crescent belt fasteners. Instructions for making a Crescent joint are given, and it contains a ready-reference service chart by means of which the correct type of belt fastener can be determined. Copies may be obtained by writing to the company.

New Construction

Proposed Work

Conn., Bridgeport—S. Z. Poli, 24 Church St., New Haven, will install a vacuum system in the 3 story theater which he plans to build on Main St. Total estimated cost, $100,000. T. W. Lamb, 644 8th Ave., New York City, N. Y., Arch.

Conn., New Haven—The New England Iron Works, Inc., 96 Commerce St., plans to build a 1 story, 60 x 150 ft. plant to include a power plant, on Albert and Welton St. Total estimated cost, $40,000.

Conn., Waterbury—S. Z. Poli, 24 Church St., New Haven, will install a steam heating system in the 1 story theater which he plans to build here. Total estimated cost, $500,000. T. W. Lamb, 644 8th Ave., New York City, N. Y., Arch.

N. Y., Iona Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build an extension to the power plant here. Estimated cost, $30,000.

N. Y., Massena—The Aluminum Co. of America plans extensive improvements and additions to its plant here. Plans include the absorption of several small power users on the Grass and St. Regis River to centralize power development.

N. Y., New York—The City Realty Co., 176 Broadway, will install a steam heating system in the 2 story, 189 x 213 ft. theater which it plans to build at 4810-4127 Broadway. Total estimated cost, $100,000. H. J. Krapp, 114 East 16th St., Arch.

N. Y., Troy—The Mohican Co., 280 Broadway, New York City, will install a steam heating system in the 3 or 4 story, 56 x 150 ft., retail market building which it plans to construct at 361 River St. Total estimated cost between $100,000 and $150,000.

N. J., Newark—The American Oil & Supply Co., 52 Lafayette St., will install a steam heating and sprinkler system in the oil plant which it plans to build on Wilson Ave. Toal estimated cost, $1,000,000. P. B. Taylor, Essex Bldg., Engr.

N. J., Verona—The Board of Freeholders of Essex County, Court House, Newark, plans to build a power plant here. Runyon & Carey, 843 Broad St., Newark, Engr.

Penn., Blairsville—S. S. Richard, Altoona, plans to build a hospital and group of institutional buildings near here, consisting of power house, administration building, laundry, etc. F. McCrooks, Jones Law Bldg., Pittsburgh, Arch.

Penn., Erie—The Griswold Manufacturing Co., 12th and Raspberry St., is in the market for a 14 in. x 6 ft. Hendy geared motor driven tool room lathe with taper attachment, a 2 in. motor driven radial drill and a 24 to 30 in. motor driven planer.

Penn., Johnstown—The Board of Directors of the School District will receive bids until Mar. 15 for the construction of the main school building and the boiler house of the group of 6 buildings, known as the William A. Cochran School, in the 8th Ward. C. H. Meyer, Secy.

Penn., McKees Rocks—The Pittsburgh Railway Co., 435 6th Ave., Pittsburgh, plans to build an addition to the power house here, also a new station at Castle Shannon and new tracks at various points. F. Uhlenhart, Ch. Engr.

Md., Baltimore—The City Electrical Commission, City Hall, plans to extend the electrical conduit system into city's new annex during spring and summer. Estimated cost between $150,000 and $200,000. P. G. Ligon, Ch. Engr.

S. C., Charleston—R. L. Riggs, 4 Broad St., will install a steam heating plant and electric elevators in the 3 story, 159 x 170 ft. garage, repair shop and storage building which he plans to build. Total estimated cost, $100,000. J. O. Newcomer, 82 Broad St., Arch.

Ga., Lyerly—The Lyerly Milling Co., is in the market for an electric generator and motor to be installed in the Sarling Mill, which they recently acquired. J. S. Owings, Mgr.

La., New Orleans—The Pelican Ship Ventilator & Metal Co. is in the market for a power drop hammer.

Ohio, Cleveland—J. Grossman, c/o Standard Theater, East 9th and Prospect St., will install steam heating and ventilating systems in the 6 story, 75 x 196 ft. theater which he plans to build on Euclid Ave., near 107th St. Total estimated cost, $300,000.

Ohio, Cleveland—D. R. Hanna, 511 Leader News Bldg., plans to install a steam heating system in the 16 story, 199 x 210 ft. office building which he plans to build on East 11th St. and Euclid Ave.

Ind., Anderson—The city has been authorized to issue $90,000 bonds with which to make improvements and install new equipment in the electric plant. J. E. Essington, City Clk.

Mich., Detroit—The Waterworks Department has applied for an appropriation for the construction of a new boiler house to accommodate a 600 hp. boiler. C. F. Hubbell, City Engr.

Mich., Wyandotte—E. C. Bryan, City Clk., will receive bids until March 18 for furnishing and installing 2 low lift, motor driven centrifugal pumping units (one 2100 gallons per minute and other 4200 gallons); also for steam driven pumping unit 5,000,000 gallon capacity, horizontal cross compound crank and fly wheel pumping engine. R. W. Pratt, Hippodrome Bldg., Cleveland, Ohio, Engr.

Ill., Chicago—L. E. Waterman & Co., 191 Broadway, New York City, N. Y., plans to install a steam heating system in the 6 story store and office building which they plan to build at 127-129 South State St. Total estimated cost, $175,000. Holabird & Roach, 104 South Michigan Ave., Arch.

Ill., Decatur—The Comet Automobile Co., 156 South Water St., plans to build a power and heating station. The growth of the business of the company necessitates same. Estimated cost, $35,000.

Iowa, Sioux City—The Terminal Grain Corp., Grain Exchange, will install about 600-hp. in electric motors, in the terminal elevator which it plans to build on 14th St., along the Great Northern Railway tracks. Total estimated cost, $140,000. Burrell Engineering & Construction Co., 323 South La Salle St., Chicago, Ill., Engr.

Kan., Ottawa—The City Water & Light Department is in the market for a new 500 kw. generating unit, including condensing equipment for electric plant; also steam engines and turbines. W. O. Myers, Supt.

Kan., Ottawa—The Warner Manufacturing Co. is in the market for a No. 7 Buffalo or a No. 4 Sturtevant cupola blower.

Neb., Omaha—The State Legislature, Lincoln, plans to appropriate $120,000 for improvements to the University of Nebraska College of Medicine, 42nd St. and Dewey Ave., to be used as follows: $40,000 for electrical apparatus, laboratory equipment, etc.; $80,000 for the construction of a 1 story, 30 x 50 ft. heating plant; also pumps, pipe covering, watertube boilers, etc. J. Latenser & Sons, 632 Bee Bldg., Arch.

Okla., Tulsa—The city will soon receive bids for installing a 150 ft. concrete stack and new boilers. R. E. Cuvian, Comr. Water-Works.

Colo., Denver—Armour & Co., U. S. Yards, Chicago, Ill., will soon award the contract for the construction of a 4 story, 58 x 162 ft. boiler house here. H. A. Merick, c/o Colorado Packing & Provision Co., Stock Yards, Denver, Arch.

Colo., Julesboro—The city will soon award the contract for rebuilding the light and power plant. G. H. Austin, Mayor. Noted Nov. 26.

Colo., Silver Plume—The Denbigh Mines Co. is in the market for a double-drum electric hoist, and a second-hand motor driven compressor. H. S. Bushnell, Supt.

Idaho, Nampa—The city plans to build flush tanks, manholes and pump to handle 200,000 gallons per day, in connection with new sewerage system. L. R. Cook, City Hall, Engr.

Ariz., Florence—The town voted in favor of a bond issue for $80,000; $60,000 to be used for water-works improvements and $20,000 for power plant. List of required equipment can be obtained from the Board of Supervisors. Noted Jan. 7.

Wash., Seattle—The Puget Sound Traction, Light & Power Co., Stuart Bldg., has had plans completed for rebuilding its power sub-station recently destroyed by fire. A. L. Kempster, Mgr.

Cal., Modesto—The Waterford Irrigation Dist. plans election soon to vote on a $200,000 bond issue; $170,000 to pay for water rights and $30,000 to extend and improve irrigation works. Pumping plant will probably be installed in Tuolumne River, to lift water 110 ft. for irrigating 13,866 acres. E. N. Bryan, Modesto, Engr.

Cal., Quincy—The Board of Supervisor of Plumas County will install a steam hea ing plant in the 1 story court house and ja which it plans to build. G. C. Sellon, Mita Bldg., Sacramento, Arch.

N. S., Sydney—The Dominion Iron & Ste Co. is in the market for material an equipment for its plant.

Ont., Parry Sound—The Town Coun plans to build an electric plant and i the market for machinery for same. Es mated cost, $185,000. J. D. Broughton, C

Ont., Renfrew—The Renfrew Machine Co., Ltd., is in the market for an electr spot welder, 110 or 550 volt, 60 cycle phase circuit.

Ont., Toronto—Hyslop Bros., Ltd., 3 Shuter St., is in the market for 1 motor generator set, direct drive, single unit base, 5 hp., 3 phase, 1800 r.p.m., gen. volts, 60 amp., capacity 30, 6 v. batteries at 10 amp., board with 6 leads, volt meter, rheostat and ammeter.

Ont., Toronto—Bids will be received b the Town Clerk, until March 7, for furnishing and installing 1 water-works pumping unit comprising turbine pump of 2000 gallon capacity against 330 ft. head an steam turbine or gasoline engine, dire connected to pump. Specifications, etc., may be seen at the office of Chipman & Power Mail Bldg.

Man., Winnipeg—The Dominion Government, Ottawa, Ont., will install a central heating plant and boilers in the Military Hospital which it plans to build at Tuxedo Park. Total estimated cost, $190,000. R. C. Wright, c/o Dept. of Pub. Works.

CONTRACTS AWARDED

N. H., Portsmouth—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing piping connections in the power house at the Navy Yard here, from the Carroll Electric Co., 714 12th St., Washington, D. C., $42,800; J. W. Danforth, 70 Ellicott Sq., Buffalo, N. Y., $42,986; Rideout, Chandler & Joyce, 178 High St., Boston, Mass., $44,158.

Mass., Millis—The Cliquot Club Co. has awarded the contract for the construction of an addition to its plant, to the Aberthaw Construction Co., 27 School St., Boston, Mass. Project includes a power house, bottling factory, etc. Total estimated cost, $150,000.

N. Y., Brooklyn—J. Kayser, 45 East 17th St., Manhattan, has awarded the contract for the construction of a 1 story, 50 x 55 ft. power house on Classon Ave., to the Caye-Hosford Construction Co., 299 Broadway, Manhattan. A steam heating system will be installed in same. Total estimated cost, $60,000.

N. Y., Iroquois—W. Hunt, Pres. of the Bd. of Managers, Thomas Indian School, received bids for installing refrigeration equipment, from the Moyer Ice Machine & Engineering Co., 315 Grant Ave., Jersey City, N. J., $9400; Mollinberg-Betz Machine Co., 110 Nash St., Buffalo, $9558; Wigner Machine Co., 67 Mississippi St., Buffalo, $9930. Noted Feb. 4.

N. Y., New Hampton—The Commissioner of Correction, Municipal Bldg., New York City, has awarded the contract for the installation and completion of the steam mains and tunnel between the receiving, classification and administration building and the power house at the New York City reformatory here, to L. W. Abrons, 15 East 40th St., New York City. Estimated cost, $4500.

N. Y., New York—Brown Bros. & Co., 59 Wall St., has awarded the contract for the construction of a 4 story, 44 x 88 ft. banking building at 81-83 Beaver St., to Marc Eidlitz & Son, 30 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $150,000.

N. Y., New York—The Daughters of Jacob, 157th St., Findlay and Fuller Ave. (Bronx Boro.), have awarded the contract for the construction of a 5 story, 100 x 150 ft. home, to G. Richard Davis & Co., 30 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $600,000.

N. Y., Utica—The State Hospital Commission, Capitol, Albany, received bids Feb. 11, for the following work at the Utica State Hospital; installing new boilers, from Gillis & Geoghegan, 537 West Broadway, New York City, $42,990; McNaull Boiler Works, 983-1015 Front St., Toledo, Ohio, $58,120; E. Keeler Co., 50 Church St., New York City, $67,920; heating work, from the W. B. Armstrong Co., Fulton St., Albany, N. Y., $39,640; Almirall Co., Inc., 1 Dominick St., New York City, $41,975; H. C. Peterson Co., 20 Oneida St., $44,963.

POWER

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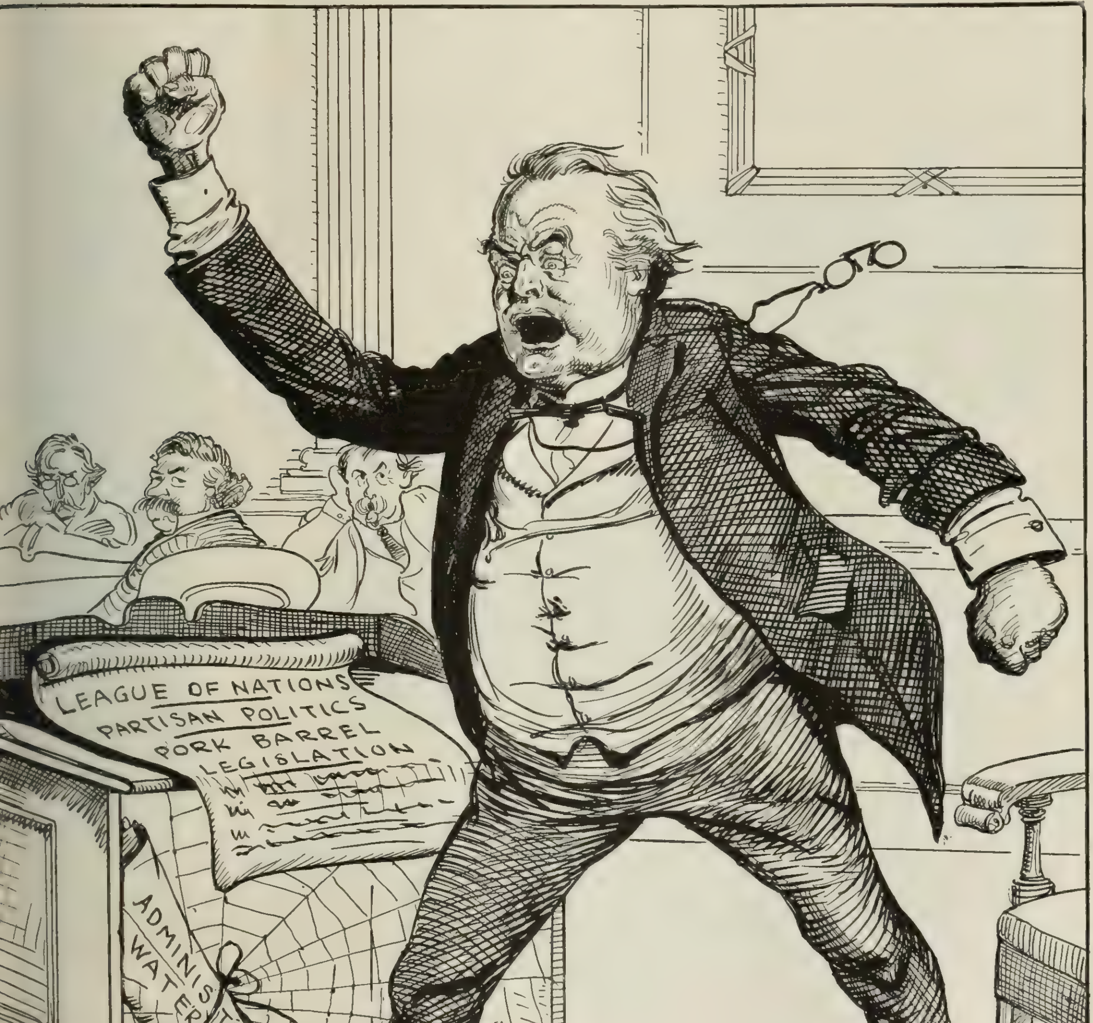


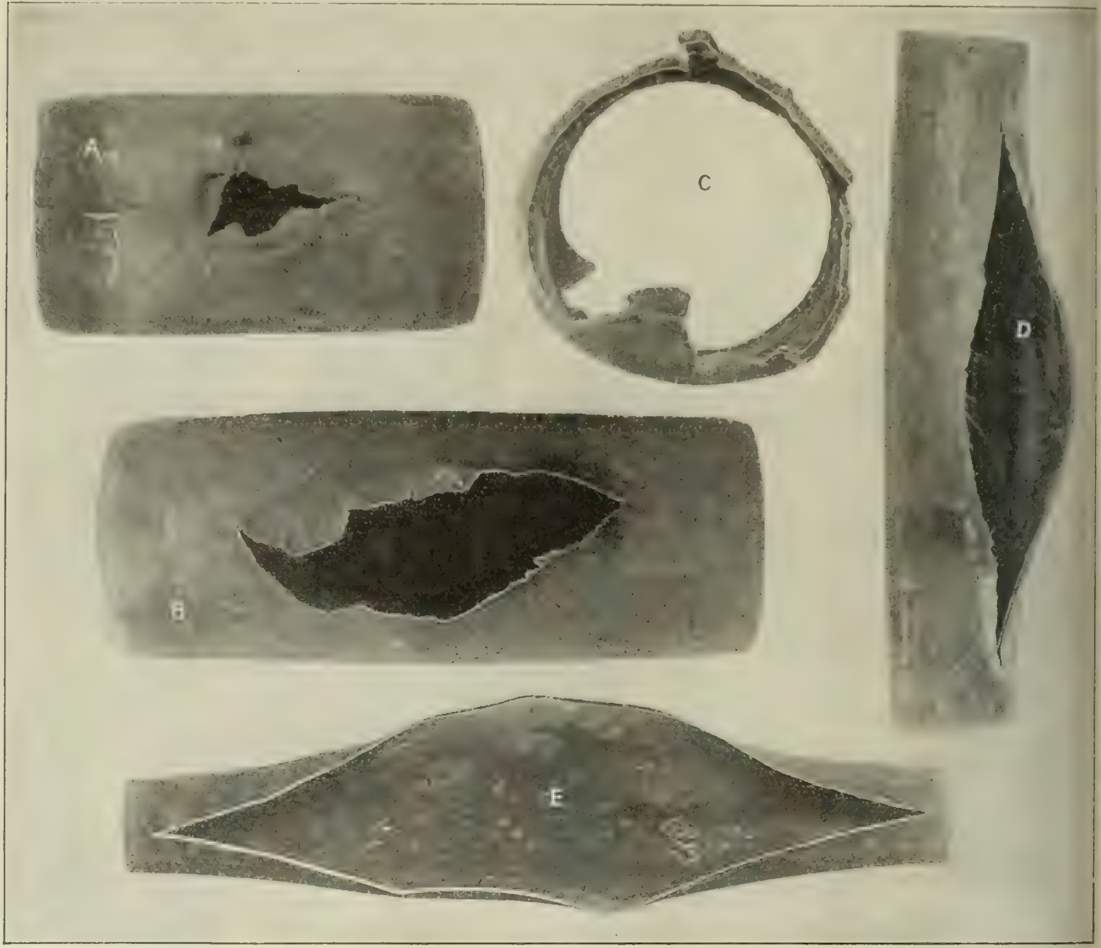
WHILE CONGRESS TALKS!

Water-Tube Boiler Tube Ruptures

By WELDON MELROY

A LARGE percentage of tube failures are unavoidable, but many ruptures may be prevented by the prompt renewal of tubes in which serious defects develop. The number of preventable tube ruptures has increased during the last year because the shortage of steel has made it imperative to get the maximum service from every tube. On account of this condition some operators have taken chances with tubes which have developed defects, and some serious ruptures have resulted.

At *A* and *B* (see illustration) are shown ruptures that were caused by overheating. The feed water used in the boiler in which these tubes were installed was very foul. The tubes that ruptured were found to contain considerable deposits of precipitated mud and organic matter, which was baked on the internal surfaces and caused the ruptures. Pockets caused by accumulations of scale and mud are frequent in water tubes, but when they are not deep and the tubes are kept clean, such pockets are not considered serious. Tubes that become distorted to such an extent that the points of the pockets can be dented by a sharp blow from a light hammer should be renewed. Efforts to heat the distorted portions and drive them back to their original radius after they have been pocketed to such an extent that the walls have been thinned, are usually unsuccessful, and there is considerable hazard in connection with operating tubes that have been treated in this manner.



TUBES FROM WATER-TUBE BOILER RUPTURED FROM SEVERAL CAUSES

Ruptures *A* and *B* caused by deposits of mud and scale. Ruptures *C* and *D* caused by crystallization. End view of tube shows condition of tube wall. Rupture *E* is of a 4-in. tube caused by a defective lap weld.

At *C* and *D* are shown sections of a tube that became crystallized to such an extent that it ruptured without warning, causing considerable damage to the adjacent tubes and boiler setting. The end view of the tube shows the coarse crystalline structure of the metal. It will be observed that only a very narrow section of the tube wall at the inside edge was not crystallized. The ruptured edges of the tube show that the tube wall as not thinned. In addition to the rupture the tube racked in a number of places. One of these cracks is hown in the illustration. The tube end was so lacking n ductility that pieces could be broken off with a blow f a hammer.

In the illustration *A*, *B*, *C* and *D* show that seamless- rawn steel tubes will rupture from overheating or eakness caused by crystallization. In addition to be- ng subject to these conditions, lap-welded tubes some- imes rupture on account of defective welds. Such uptures are usually violent and cause serious damage. t *E* is shown a rupture of a lap-welded tube about our months after its installation, under a pressure of 40 lb. That the weld was defective is shown. The rincipal reason for the use of lap-welded tubes in water-tube boilers is the fact that under present conditions they are considerably cheaper than seamless-drawn tubes.

When the damage caused to boiler settings, the injuries suffered by the operating force in the boiler rooms and the interruption to the service caused by tube ruptures are considered, it will be seen that there is nothing gained by operating boilers in which there are tubes that are suspected of being defective. When tubes show signs of crystallization or become dangerously distorted, they should be renewed. Efforts to restore ductility to crystallized tubes by annealing or to drive back deep pockets are so uncertain that such measures cannot be considered safe or satisfactory methods of repair.

Effect of Interpoles on Commutation of Direct-Current Machines

By R. L. WITHAM
Assistant engineer, Sperry Gyroscope Co., Brooklyn, N. Y.

The construction of the interpole direct-current machines is described. The purpose of the interpoles and how they operate to effect commutation and how one interpole may be used for each pair of main poles to serve the same purpose as an interpole for each main pole are explained.

THE interpoles in a direct-current machine, when used, are small poles placed between the main poles. It is from their location that they get their ame, the prefix "inter" meaning between or among. irect-current machines may have as many interpoles s there are main poles, or they may have one interpole or each pair of main poles. Fig. 1 shows the field rame of a four-pole compound-wound interpole machine aving one in- erpole *A* for ach main pole , where the achine Fig. 2 as only one in- erpole *A* for ach pair of ain poles *B*. he use of in- erpoles on di- ect-current ma- hines is today lmost uni- ersal. Ten or welve years ago heir use was a ovelty. Yet he fundamental dea of which hese commutating poles are but the materialization is y no means a new one. Why, then, have they come nto such general use and how does their use affect the peration of the machine of which they are a part? To nswer these questions it is necessary first to consider their purpose and in what manner it is fulfilled.

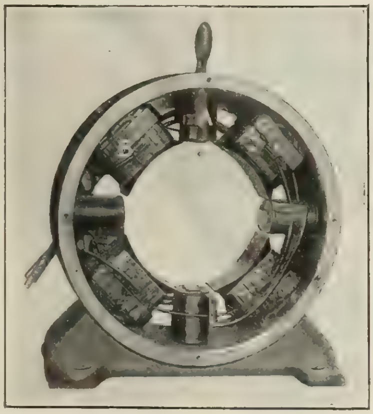


FIG. 1. FOUR-POLE MOTOR HAVING FOUR INTERPOLES

Briefly stated, the purpose of interpoles is to assist in commutation. Because of this they are also known as commutating or auxiliary poles. In any direct-current machine the current in the armature coils is alternating; that is, while any one coil is passing across the face of a north pole of the machine it carries current in a certain direction, but that direction is reversed when the coil moves across the face of the next consecutive, or south, pole.

Fig. 3 represents diagrammatically a part of the winding of a direct-current armature, the small arrows showing the direction of current in the coils. Assuming that current flows downward in the conductors under a north pole, it will flow upward in the conductors under a south pole and in those midway between poles there will be no current. The armature is assumed to be moving from left to right as indicated by the large arrow. It will be seen that the direction of current in a coil which is approaching a brush (as for example, coil *A*) is clockwise, while the direction of current in a coil which has passed the brush (as for example, coil *C*) is counterclockwise. This shows that while the coil in question was passing under the brush, its current was reversed in direction. This reversal of current in the armature coil is what is known as commutation.

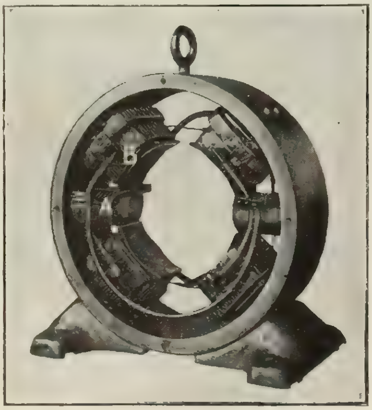


FIG. 2. FOUR-POLE MOTOR HAVING TWO INTERPOLES

Assuming a brush 0.5 in. wide and a peripheral speed of commutator of 2500 ft. per min., or 500 in. per sec., it will require 0.001 of a second for a given point on the commutator to travel the width of the brush, and in this brief period the current in a coil undergoing commutation must be reduced from its normal value to zero and be built up to its normal value again in the opposite direction if commutation is to take place without sparking. What force can be made to act upon the coil in such a way as to produce this change in current in so short a time? The way to produce any desired change in current in a coil is to set up an electromotive force in that coil, and the way to set up the required electromotive force is to so arrange conditions that the coil will cut lines of magnetic force of the proper polarity and strength.

The laws governing the generation of electromotive force and current by cutting lines of force is clearly explained in that part of "The Electrical Study Course" appearing in the Nov. 20, 1917, issue of *Power*. A glance at Fig. 3 will show that when a coil is in such a position that it is short-circuited by a brush (as for example, coil *B*) the conductors that compose that coil are midway between poles and at these midpoints the magnetic flux due to the poles is zero.

This condition is more clearly shown in Fig. 4, which represents the distribution of flux in the air gap between the poles and armature. In order to provide for this coil a magnetic flux of such strength and polarity that it will set up the electromotive force required to commutate its current either of two things may be done: (1) The brushes may be shifted until commutation takes place when the coil is in some such position as shown i Fig. 5, where the desired flux is furnished by the mai pole; or (2) without shifting brushes, a set of sma poles, known as commutating poles or interpoles, ma be introduced midway between the main poles to pro vide the necessary flux at that point, as illustrated i Fig. 6. When the latter method is used, we have th interpole machine.

Having shown that the purpose of the interpole is t produce a commutating field midway between the mai poles, consider next in what way the interpoles shall b supplied with the magnetizing current. If the inte pole winding were excited from a source of constan potential, as is the case with the shunt-field windin the commutating flux thus established would be constan regardless of the load on the machine. But this is n what is desired. If a machine is carrying a current o 200 amperes, it requires twice as strong a commuta ing field for perfect commutation as when the same ma chine carries 100 amperes. In other words, the strengt of the commutating field should vary directly with th ampere load on the machine. This result is approx imately accomplished by connecting the commutatin winding in series with the armature winding and work ing the iron of the interpole at such a low magneti density that it is always unsaturated. Then the arma ture current can be made to vary between wide limit and the commutating-field strength will vary with it, jus as it should. The number of turns per coil of the in terpole winding, the length of air gap and the widt and shape of interpole face all have their effect on th

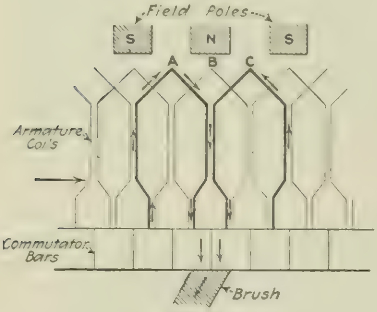


FIG. 3

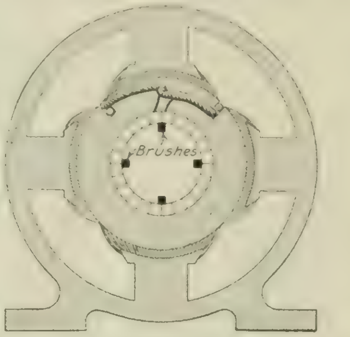


FIG. 4

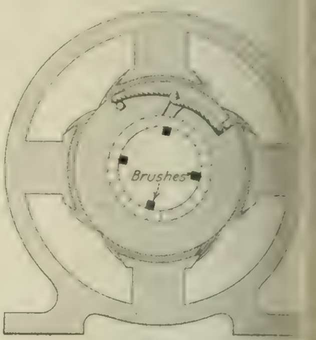


FIG. 5

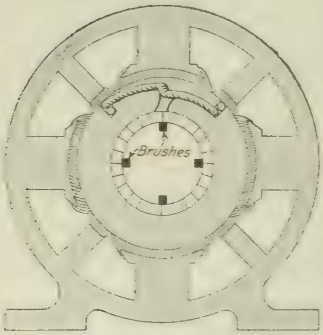


FIG. 6

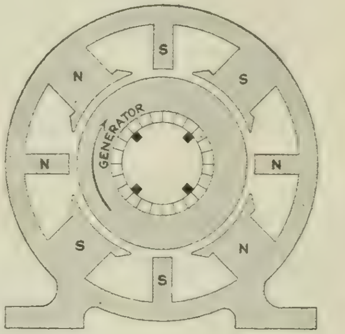


FIG. 7

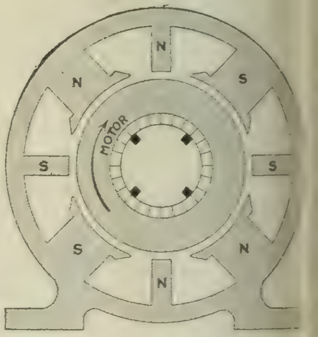


FIG. 8

FIGS. 3 TO 6. FIELD FRAMES OF NONINTERPOLE AND INTERPOLE DIRECT-CURRENT MACHINES strength and distribution of commutating flux and hence upon commutation, but the proper adjustment of these elements is a matter for the designer of the machine to determine and will not be considered here.

Fig. 7 shows the polarity of the interpoles in the case of a generator and Fig. 8 that of a motor, the direction of rotation being taken as clockwise in both cases. If the direction of rotation is reversed, the polarity of the commutating poles should be reversed.

Fig. 9 represents a four-pole machine in which are shown the four armature coils which at a given instant are short-circuited by their respective brushes. Since coil 1 is made up of conductors lying in both slots *A* and *D*, an interpole placed at either *A* or *D* will have the effect of setting up the flux needed for commutating the current in coil 1. In like manner good commutation in coil 2 may be brought about by an interpole placed at either *A* or *B*. Similar statements may be made regarding coils 3 and 4. In other words, a commutating pole placed at *B*, if properly magnetized, will take care of commutation in both coil 2 and coil 3, and a similar ommutating pole placed at *D* will take care of commutaion in coils 1 and 4. It follows, then, that interpoles t *A* and *C* may be dispensed with if those at *B* and *D* re of suitable strength.

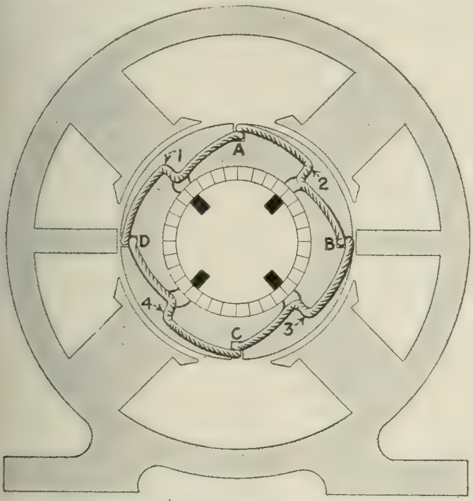


FIG. 9. FIELD FRAME HAVING FOUR MAIN POLES AND TWO INTERPOLES

In general, in any machine, the number of interpoles nay be made either equal to or half of the number f main poles. The usual practice is to use as many nterpoles as main poles when the number of pairs of nain poles is odd. For example, in a six-pole machine ix interpoles and in a two-pole machine two interpoles re used. There is, however, no reason why a six-pole nachine with three interpoles or a two-pole machine vith only one interpole will not operate as well as a our-pole machine with two interpoles as in Fig. 2, the ast arrangement being a very common type of contruction. When the number of commutating poles is alf the number of main poles, the commutating poles re all of the same polarity; that is, they are either all orth or all south poles.

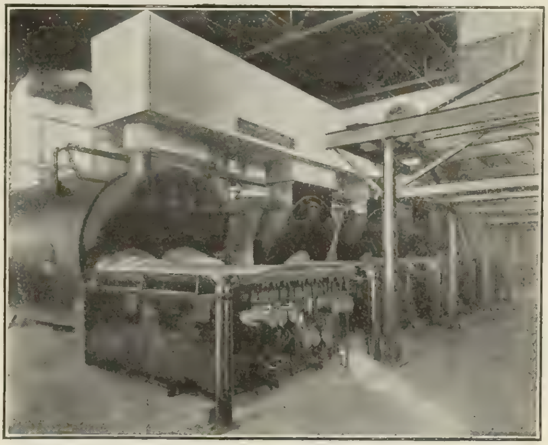
There are certain cases in which a machine should ave as many interpoles as main poles. One instance is in three-wire generators, where, for the sake of securing a perfect balance on both sides of the neutral wire, it is required that all the north-pole commutating windings be connected in on one side of the line and all the south-pole windings on the other. Obviously, if the interpoles are all north or all south poles, which, as has already been stated, is the case when there are only half as many of them as there are of main poles, this balanced condition is impossible.

(A subsequent article will explain how interpoles influence the other characteristics of direct-current generators and motors.)

Heating Plant of New State Capitol of Oklahoma

By J. Earl Pullen

The steam-heating plant of the new state capitol at Oklahoma City, Okla., contains a number of interesting features, some of which are illustrated in the accompanying view of the boiler room. Five single-ended Scotch marine boilers having a total of 1250 boiler horsepower supply steam to the capitol building, the pipes being run through a 750-ft. tunnel. One of the boilers has two furnace flues and the other four are of the single-flue type, but all are fitted with McMillan dutch-oven furnaces. Gas is used as fuel, each furnace having nine Gwynn gas burners, arranged in groups of three, as shown. After leaving the boilers the gases pass through a Sturtevant economizer located overhead on a suitable framework. The remainder of the equipment consists of a duplex boiler-feed pump, two vacuum pumps and an air compressor. The plant has been in operation since late in 1918.



BOILER ROOM OF OKLAHOMA STATE CAPITOL HEATING PLANT

A horizontal return-tubular boiler made without a steam dome is generally provided with a dry pipe. This consists of a perforated pipe of large diameter having a length equal to about one-third or one-half the length of the boiler. It is attached to the upper part of the shell on the inside and is connected to the steam pipe leading to the main steam header or to the engine, as would be the case where but one engine is in service.

Care of Heating and Ventilating Equipment—VIII

By HAROLD L. ALT

In this article vacuum-heating systems are discussed, their operation and care, the troubles to which they are subject, and how these troubles may be avoided and the system kept operating at good efficiency.

THE vacuum system of steam heating so commonly applied to buildings involves drawing back both the condensate and air from the system with a vacuum pump, which discharges the mixture of air, water and vapor into a separating tank. The air and vapor pass off through a vent pipe, while the water may be returned to the boiler. A typical vacuum installation is illustrated in Fig. 1. The chief characteristics of such a system are quick action, graduated heat control at the radiators, small return pipes and its suitability for large installations. It is quite commonly used where exhaust steam is utilized for heating and in groups of buildings where large areas of ground are covered. Steam is supplied to a vacuum system usually under a slight pressure above that of the atmosphere and may run up to 5 or 8 lb. gage and is supplied to the radiators through an ordinary radiator valve or through a valve with a graduated action so that any desired proportion of the radiator surface may be heated.

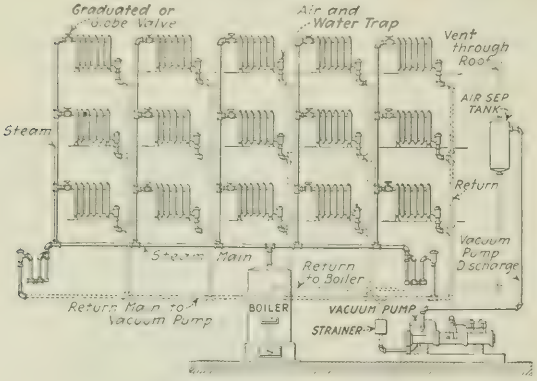


FIG. 1. A TYPICAL VACUUM HEATING SYSTEM

All types of graduated valves depend upon reducing the size of inlet orifice so that only part of the steam necessary to heat the radiator is admitted in the intermediate positions, and steam or vapor may occupy only a part or all of the radiator. Radiators of the hot-water type, as shown in Fig. 2, are used with the graduated valve set in various positions. The steam or vapor being lighter than the air in the radiator, it seeks the top. To prevent pulling steam down into the return line and breaking the vacuum, traps are placed on the return end. These traps operate on the same principle as radiator air vents already described, passing air and water but not steam. Some traps for this purpose have a small permanent opening to pass a little air or vapor at all times in order to keep the radiator free, but the discharge of steam through this orifice is so small that it is condensed in the return line before getting back to the vacuum pump.

Such traps operate on one of two principles—either thermostatic (expansion) or the float (water-seal) action. The first trap developed for such work was of the expansion type, like the automatic air valve previously described, but it had a very small movement so that the outlet was easily clogged and scale or grit lodging on the seat was liable to injure the expanding part by preventing its proper elongation. These troubles proved so objectionable that the water-seal trap was evolved, in which a small float rises and gives a full opening whenever a slug of water comes along and air relief is obtained at all times through the small opening through the valve. Later, other forms of expansion valves were made that are entirely satisfactory.

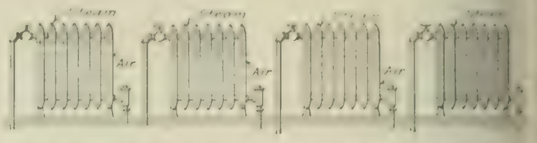


FIG. 2. RADIATORS REPRESENTED PARTLY OR WHOLLY HEATED

Little difficulty in operation is encountered with the supply valves, but with the return traps the case is different, for these, operating only by expansion or gravity, are easily troubled by scale or dirt, some of their ills being sticking, water-logging, cracking, etc. This is especially true of the older and more obsolete types, while the more modern designs have to a greater extent minimized these troubles. The vacuum system will operate with more faults in the piping than any other because the vacuum helps the return back past obstructions and through smaller lines than could be used with a gravity system. The thing that must be observed above all others is that no connection can be made between the steam main and the return line except

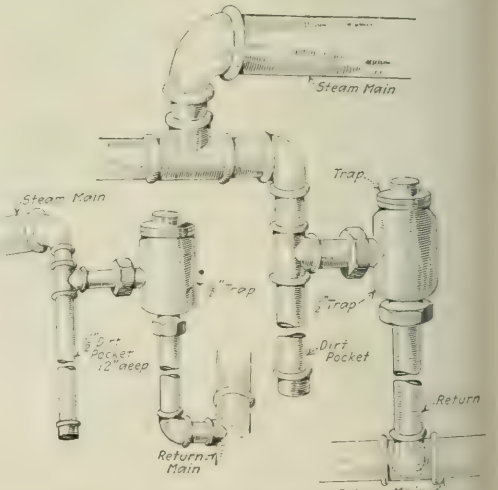


FIG. 3. DIRT POCKETS NEAR TRAPS

hrough a trap. The drip piping from the steam main ftentimes determines whether the system is going to perate satisfactorily or not, and if the main drips do ot properly relieve the water, trouble will result. The ard service required of a main drip trap has led some ianufacturers to produce a "drip" trap of heavier con- truction than the return or radiator trap, suitable for ard service. Where a trap is used to drain a header, irt and sediment should, by all means, be kept out of ie trap. This can best be accomplished as shown in 'ig. 3 or 4, in which loose particles fall into the dirt ocket made of 1½-in. pipe. If this dirt pocket is made 2 in. deep, it will probably accommodate all the scale iat will ever come along—at least it will serve withut attention for many years. Still better results are btained if a water seal, as shown in Fig. 4, is interosed between the steam main and the trap to protect ie expansion mechanism from the destructive slugs f water which sometimes shoot along the main when he steam is first turned on, and it also allows the drip to cool down to a point where the thermostatic member will be in contact with water cold enough to cause it to operate. In fact, one objection to the thermostatic trap is that hot condensation will not cause the trap to open and the water will be held at the trap until it cools. The customary method of piping steam in such systems consists of starting at a high point and pitching down to a point where another rise is desirable or where a drip is necessary, then make the rise in the main and connect a drip at this point, continuing in this manner to the end of the main, where the last drip connection is made in the manner illustrated in Fig. 3 or 4. For best operation drips on the steam main should not be more than 100 ft. apart and on straight mains should be made as shown in Fig. 3.

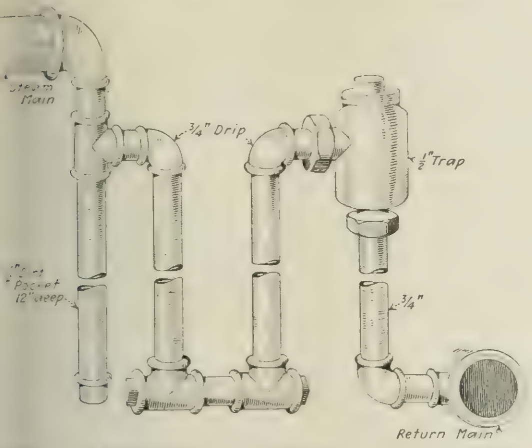


FIG. 4. WATER SEAL IN ADDITION TO DIRT POCKET

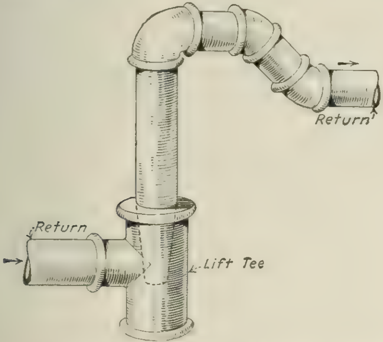


FIG. 5. LIFT FITTING FOR VACUUM SYSTEM

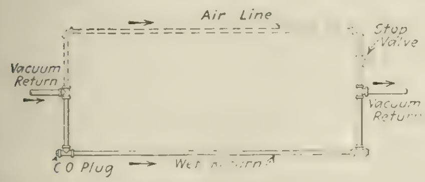


FIG. 6. AIR-LINE METHOD OF PASSING DOORWAYS

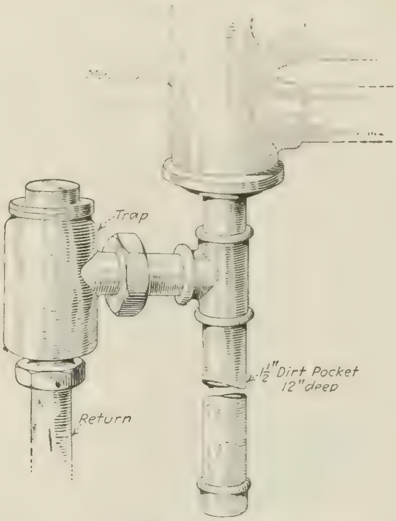


FIG. 7. DRIP CONNECTION FROM A COIL

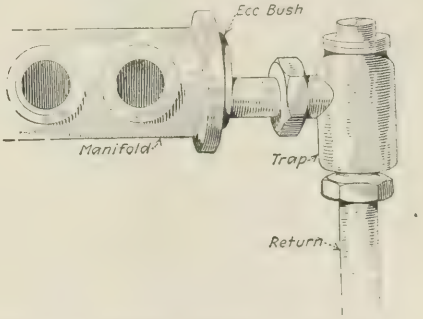


FIG. 8. ECCENTRIC BUSHING IN MANIFOLD

Owing to the vacuum return handling both air and water, because no automatic air valves are used on the radiators, the return cannot be raised at any point without water sealing and preventing the escape of the air. There are two ways of accomplishing this, one being by means of a lift fitting arranged as shown in Fig. 5 and the other by a water seal in the return line and providing a separate air line to bypass the seal, as shown in Fig. 6. Where returns are carried above the floor, difficulty occurs at doorways, but this may also be solved by the air-line method, as shown in Fig. 6. If it is desired to empty the line of water that would otherwise be retained, the simple installation of a single valve in the air line as indicated will make it possible to draw all the water out by suction when these valves are closed and the vacuum pump run a short time at the end of the season.

Where leaky traps are giving trouble by vapor getting into the steam line, a remedy of more or less permanent nature will be found in connecting a small cold-water line to the vacuum return close to the vacuum pump. This line is sometimes connected to the pump strainer (which should always be used) and is used to supply a small quantity of makeup water at all times, while others use a special cast-iron condensing chamber or surface condenser in which the uncondensed vapor is brought into contact with the cold-water tubes, resulting in an almost perfect vacuum. The cold water supplying the house service, heaters or boiler-feed line is carried through these tubes in series and keeps them cool. In order to keep the system operating at a good efficiency, the pump strainer should be cleaned frequently, the periods of cleaning being more frequent in new systems and decreasing as the system becomes gradually more and more cleaned out.

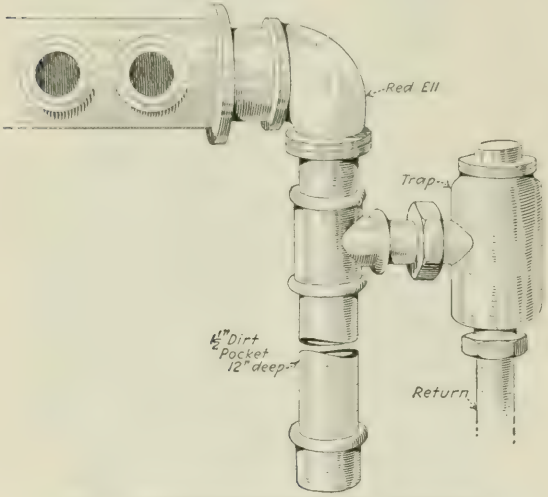


FIG. 9. REDUCING ELBOW FOR DRAINAGE

Pipe coils are not treated quite the same as radiators in the matter of connecting traps. While on the radiators no strainers or dirt pockets are used, these are recommended on large pipe coils, being placed between the coil and the trap with the strainer arranged so that the particles will fall into the wire basket, which may be easily removed and emptied. On wall coils the bottom of the manifold is commonly bushed to 1½-in. pipe and the regular drip connection made as shown in Fig. 7; but if the coil lies horizontally, as is the case with ceiling coils, the return connection can be made by the use of an eccentric bushing (Fig. 8) or, better still, with a reducing ell and regular connection (Fig. 9). Where steam mains lie below the return lines or where the drip connections throw the trap outlet below the level of the return line, it is perfectly permissible to lift the trap discharge for a small distance (say not to exceed three feet) as shown in Fig. 10; because a trap in such a location does not necessarily handle air. In handling water alone the water sealing of the trap discharge by lifting it to a higher level is not objectionable provided there is ample opportunity for the air to escape elsewhere. Of course, if such a connection is to be used when air must be considered, a regular lift fitting must be used.

In a case where more than one building is connected to a system, it is sometimes desirable to place a vacuum regulator on each building so that any desired vacuum can be carried on any building, and a building with sluggish circulation can be helped out by increasing its vacuum slightly. This is accomplished by employing a trap that passes the water of condensation as fast as it is produced, but has a diaphragm control on the air-line bypass around the trap, so that any desired degree of vacuum can be placed on any building as desired. The connections around such a trap are illustrated in Fig. 11 and are self-explanatory. Of course, the vacuum on the main line must equal or exceed the highest vacuum expected to be maintained in any building.

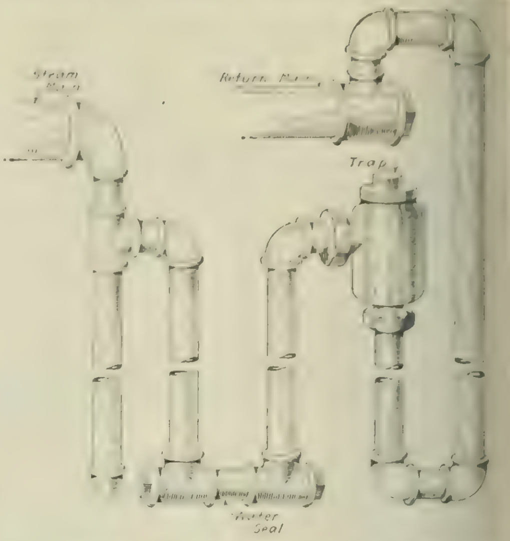


FIG. 10. POSSIBLE CONNECTION IF NO AIR IS PRESENT

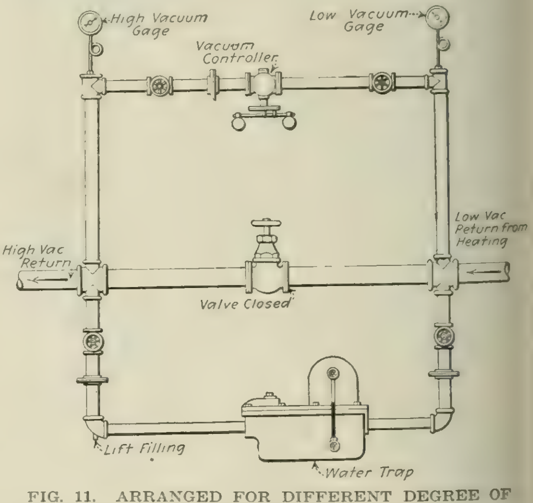


FIG. 11. ARRANGED FOR DIFFERENT DEGREE OF VACUUM

Statistical Analysis of the Central Electric Stations of Canada

Figures showing the various kinds and amounts of power in Canadian central electric stations, capital invested and salaries and wages paid, with data of especial interest concerning hydro-electric power.

GROWTH of the central-station industry in Canada has been rapid, particularly during recent years. The larger electric systems, both mmercial and publicly owned, have been widely ex-nded from year to year, opening up new territory in e electrical-distribution field.

To measure properly the scope of the industry and gage its importance to commercial and industrial terests, the Dominion Water Power Branch of the epartment of the Interior, in coöperation with the ominion Bureau of Statistics of the Department of ade and Commerce, has had under way during the st year an exhaustive analysis of the central electric ations of the Dominion. As some time must elapse fore the complete report can be published and dis-ibuted, a brief synopsis of the statistical data has en prepared.

In considering the statistics that are summarized reunder, it should be borne in mind that the figures ve reference solely to central electric stations; that to stations engaged in the distribution and sale of ectrical energy. Where central stations were inter-oven with other activities, such as the operation of ectric railways, mines, pulp mills or other industrial terprises, the central-station equipment, capitalization d other statistical data secured have been wholly vorced from the allied industry. This line of sever-ce has been drawn through the entire statistical alysis. Central stations purchasing power in bulk r purposes of resale are included in the financial d staff statistics.

The total number of central electric stations re-rded is 666, of which 323 are commercial stations d 343 are municipal. Examination of the figures, wever, shows that the excess in municipal stations attributable to the nongenerating station. Of the ations with generating equipment 296 are commercial d 174 are municipal. Of the stations without gen-ating equipment 27 are commercial stations and 169 e municipal. The hydro-electric power system of Ontario is largely responsible for the large proportion of municipal stations purchasing power in bulk.

Table I summarizes by provinces the number, kind and horsepower of the primary power machines installed in central electric stations on Jan. 1, 1918. The primary power totals 1,844,571 hp., of which 78.3 per cent., or 1,444,314 hp., is installed in commercial stations and 21.7 per cent., or 400,257 hp., in municipal stations. Of the total primary horsepower installed 1,652,661 hp. is derived from water, 180,200 from steam and 11,710 from gas and oil. From these figures it will be noted that 89.6 per cent. of the entire primary power in central stations in Canada is derived from water.

One of the most important features of the statistics in Table I is the outstanding position which water power takes in the central-station field. Out of a total installed primary capacity of 1,844,571 hp., 1,652,661, or practically 90 per cent., is derived from water. This figure is indicative of the extent and availability of the water-power resources of the Dominion and of the remarkable degree to which their adaptability for central electric station work has been appreciated in principle and realized in practice. The vast water-power resources of the Dominion, the ready adaptability of hydro power to the production of electrical energy and the increasing extent and scope of economical electrical transmission, form an industrial asset which probably more than any other will insure a full measure of future prosperity.

TABLE I. NUMBER, KIND AND HORSEPOWER OF PRIMARY POWER MACHINES, 1917

	Total Primary Power			Kind of Power: Total Steam			Steam Engines			Steam Turbines			Gas and Oil Engines			Water Wheels and Turbines			Total Primary Power	
	No.	Horsepower Total	Per Cent. of Total	No.	Horsepower Total	Per Cent. of Total	No.	Horsepower Total	Per Cent. of Total	No.	Horsepower Total	Per Cent. of Total	No.	Horsepower Total	Per: Cent. of Total	No.	Horsepower Total	Per Cent. of Total	Commercial Stations	Municipal Stations
nada.	983	1,844,571	100	251	180,200	9.8	207	53,312	2.9	44	126,888	6.9	113	11,710	0.6	619	1,652,661	89.6	1,444,314	400,257
erta.	82	75,417	4.1	57	41,862	55.5	47	12,162	16.2	10	29,700	39.3	11	975	1.3	14	32,580	43.2	49,312	26,105
ish Columbia..	86	232,648	12.6	22	21,808	9.4	16	3,308	1.4	6	18,500	8.0	12	1,815	0.8	52	209,025	89.8	219,990	12,658
nitoba.........	41	67,337	3.6	15	2,575	3.8	15	2,575	3.8	..	....	....	11	662	1.0	15	64,100	95.2	24,888	42,449
w Brunswick	40	17,733	1.0	20	9,790	55.2	17	5,890	33.2	3	3,900	22.0	5	1,065	6.0	15	6,878	38.8	15,488	2,245
va Scotia. . . .	55	17,444	0.9	39	13,950	80.0	36	7,830	44.9	3	6,120	35.1	2	140	0.8	14	3,354	19.2	13,855	3,589
tario...........	352	784,665	42.5	43	31,745	4.0	37	8,845	1.1	6	22,900	2.9	11	1,917	0.3	298	751,003	95.7	521,396	263,269
nce Ed. Isl......	10	1,226	0.1	2	425	34.7	2	425	34.7				3	631	51.4	5	170	13.9	1,226	
ebec...........	232	606,082	32.9	22	30,245	5.0	16	4,745	0.8	6	25,500	4.2	6	286	0.1	204	575,551	94.9	586,851	19,231
katchewan.....	81	31,759	1.7	29	27,540	86.8	20	7,472	23.5	9	20,068	63.3	52	4,219	13.2	...	....	....	1,048	30,711
kon.	4	10,260	0.6	2	260	2.6	1	60	0.6	1	200	2.0	.		..	2	10,000	97.4	10,260	.

Table II presents the principal features of the statistics respecting employees, salaries and wages. For the entire Dominion the number of employees in central electric stations totals 8847, with salaries and wages aggregating $7,777,715. Of this total 5135 are employed in commercial stations with salaries aggregating $4,290,505, and 3712 in municipal stations with salaries totaling $3,487,210. The total number of employees throughout the Dominion averages 4.8 per thousand installed primary horsepower. The total salaries and wages paid average $4.22 per annum per installed primary horsepower. Reference to the salaries and wages per installed power capacity discloses the fact that those provinces in which are located extensive transmission systems of large central-station systems, show a low salary and wages bill per installed horsepower capacity. These extensive systems are in all cases founded upon water-power installation. On the other hand in those provinces where central-station industry is wholly or largely confined to individual stations for local purposes, the unit salaries and wages cost per installed capacity is high.

A few of the outstanding financial features of the industry are set out in Table III. The capital actually invested in central electric-station industry totals $356,004,168, of which 79.5 per cent. is invested in commercial stations and 20.5 per cent. in municipal or publicly owned stations.

The capital indirectly dependent upon electrical energy is enormous. No attempt has been made to go into this phase in this report. As showing the general dependability of the modern community upon electrical energy, reference might be made to the City of Winnipeg. According to a very careful and complete analysis made by the Dominion Water Power Branch in 1915 of the interests in Winnipeg which were to a greater or less degree dependent upon hydro-electric power derived from the Winnipeg River, it was shown that capital was involved to the extent of $169,260,963, and this on a power installation of only 55,400 hp. The total revenue received from the sale of electrical energy in 1917 was $44,536,848, of which $27,135,399 was secured by commercial and $15,401,449 by municipal plants.

In securing the statistics concerning capital, the actual cash investment in the central-station activities was called for, apart from the consideration of stock and bond issues. The resulting figures are therefore of particular interest as a basis for determining the investment cost per horsepower installed. The figures indicate that the actual average cost per installed horsepower for the Dominion is $193. This cost includes all capital invested in construction and equipment of hydraulic works, power stations, transmission and distribution systems; real estate; cash on hand; current assets; supplies, and all other similar items.

Of special interest are the figures relating to the capital invested in hydro-power central stations. The average capital cost per installed horsepower for the Dominion is $188. Referring to the table, the investment per turbine horsepower in Alberta appears remarkably low. This is partly explained by the fact that in the analysis the distribution system in the City of Calgary is not charged to the hydraulic developments serving the city.

Of special interest is the actual cost of construction of hydro-electric power stations per installed horsepower. Omitting all real estate, transmission and distribution equipment, seventy representative hydro-electric stations throughout the Dominion with an aggregate turbine installation of 745,797 hp. and a total construction cost of $50,740,468 show an average cost of $69.11 per installed turbine horsepower. The figure in brief represents the average capital cost of construction at the power site and is of considerable interest to engineers.

A comparison of the central-station statistics of Canada with similar figures in the United States would be of interest. Unfortunately, the 1917 census returns of the United States will not be ready for publication for several months. While it is scarcely fair to compare the 1917 returns with the 1912 returns of the United States, the figures may be instructive. The proportion of central-station power derived from water in Canada is practically 90 per cent. In the United States in 1912 the hydro-power portion was 30 per cent. of the total. The water power used in central-station work in Canada averages 198 installed horsepower per thousand population. In the United States in 1912 the similar figure was 24.7 hp. per thousand population.

While the ratios in the United States have undoubtedly very materially increased during the past five years, there is little doubt that the ratios for the Dominion are substantially in advance of those in the United States. The fundamental reason underlying the great use of water power in central-station work in Canada lies in the fact that with but two or three exceptions, every city of importance in Canada is served with central-station power from hydro-power stations. In other words, practically all the commercial and industrial centers of the Dominion are within easy transmission distance of ample supplies of economically developed hydro-electric power.

TABLE II. TOTAL NUMBER OF EMPLOYEES, AND SALARIES AND WAGES PER PRIMARY HORSEPOWER INSTALLED

Division	Total Primary Horsepower Installed	Salaried Employees and Wage-Earners Total Number	Salaried Employees and Wage-Earners Per 1000 Hp. Installed	Salaries and Wages Total	Salaries and Wages Per Hp. Installed	Commercial Stations Total Employees	Commercial Stations Total Salaries and Wages	Municipal Stations Total Employees	Municipal Stations Total Salaries and Wages
Canada	1,844,571	8,847	4 8	$7,777,715	$4 22	5,135	$4,290,505	3,712	$3,487,210
Alberta	75,417	438	5 8	458,423	6 08	156	152,652	282	305,771
British Columbia	232,648	453	2 0	496,081	2 13	310	357,488	143	138,59
Manitoba	67,337	405	6 0	433,262	6 44	79	66,669	326	366,593
New Brunswick	17,733	215	12 1	155,164	8.75	178	125,945	37	29,219
Nova Scotia	17,444	288	16 5	227,874	13 07	235	193,314	53	34,560
Ontario	784,665	4,147	5.3	4,063,060	5 18	1,777	1,920,659	2,370	2,142,401
Prince Edward Island	1,226	23	18 8	17,402	14 19	23	17,402		
Quebec	606,082	2,476	4 1	1,514,186	2 50	2,301	1,361,153	175	153,033
Saskatchewan	31,759	363	11 4	348,952	10 98	37	31,912	326	317,040
Yukon	10,260	39	3.8	63,311	6 17	39	63,311		

TABLE III. CAPITAL INVESTED IN CENTRAL STATION INDUSTRY AND IN HYDRO POWER CENTRAL STATIONS

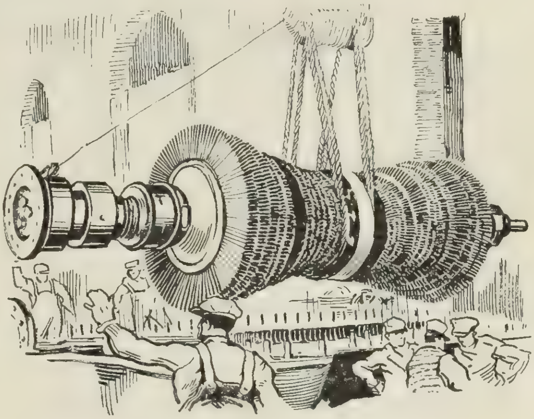
	In All Central Electric Stations					In Hydropower Central Electric Stations		
		Total Capital Invested					Total Capital Invested	
	Total Primary Horsepower	Amount	Per Primary Horsepower	Total in Commercial Stations	Total in Municipal Stations	Total Turbine Horsepower	Amount	Per Turbine Horsepower
Canada	1,844,571	$356,004,168	$193	$282,818,495	$73,185,673	1,652,661	$310,104,658	$188
Alberta	75,417	11,102,620	147	5,634,479	5,468,141	32,580	2,293,537	70
British Columbia	232,648	43,548,492	187	41,255,719	2,292,773	209,025	41,045,100	196
Manitoba	67,337	12,078,173	179	3,460,220	8,617,953	64,100	11,493,274	179
New Brunswick	17,733	3,443,848	194	2,941,569	502,279	6,878	1,315,723	191
Nova Scotia	17,444	3,376,405	194	2,776,101	600,304	3,354	686,705	205
Ontario	784,665	142,777,379	182	96,538,585	46,238,794	751,003	129,342,065	172
Prince Edward Island	1,226	211,900	173	211,900		170	48,400	285
Quebec	606,082	130,213,470	215	126,080,992	4,132,478	575,551	120,516,166	209
Saskatchewan	31,759	5,590,515	176	257,564	5,332,951			
Yukon	10,260	3,661,366	357	3,661,366		10,000	3,363,688	336

ITALY UTILIZES VOLCANIC POWER

THE enormous price of coal in Italy has resulted in the realization of an idea which at first thought seemed visionary, but which has been developed in a marvelous manner and is assuming considerable importance; this is the industrial exploitation of the natural heat emitted from the soil in those regions more or less volcanic in character.

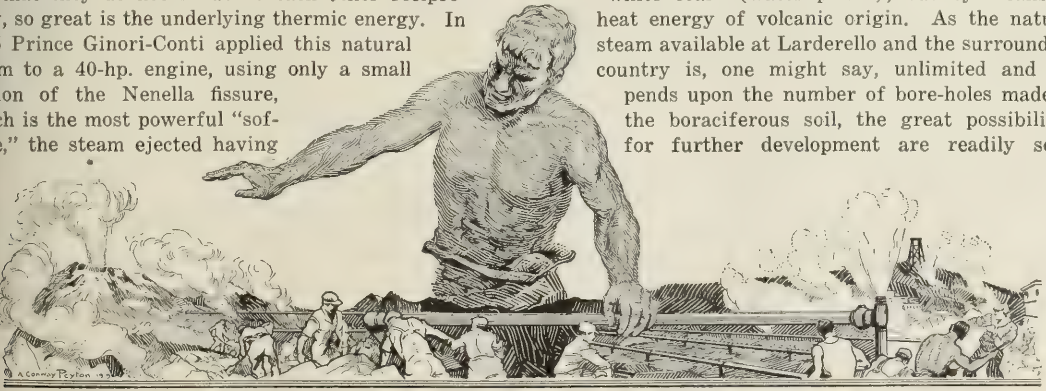
The first experiments along this line were made some years before the war by Prince Ginori-Conti, in Tuscany, at Larderello, near the salt mines of Volterra, a region extensively covered with volcanic formations, the most wonderful being the so-called "soffioni," which are certain volcanic vents emitting powerful jets of very hot steam containing boric salts and various gases used in the extraction of boracic acid. Instead of limiting the use of these steam jets, as in the past, to extracting the salts contained in the exhalations of these natural apor vents, the ejection of the steam is stimulated by oring holes. In this way it is possible to obtain powerul jets at a pressure of two to three atmospheres, ccording to the locality, and in some exceptional intances as high as five atmospheres, the temperatures arying from 150 to 165 deg. C. These jets maintain heir force and temperature unchanged for many years, nd they are not affected even when other openings, ot too near each other, are bored in the ground, provng that they do not influence each other reciproally, so great is the underlying thermic energy. In 905 Prince Ginori-Conti applied this natural team to a 40-hp. engine, using only a small ection of the Nenella fissure, hich is the most powerful "sofone," the steam ejected having a pressure of five atmospheres. The results obtained during several years of experimentation were satisfactory, so that he continued to make larger and deeper borings, measuring the force of the steam ejected; combined, this force could operate engines of many thousand horsepower. In 1912 an experiment was made, very wisely on a more modest scale, but sufficient to obtain conclusive results, for which a 300-hp. turbine-alternator was used.

Later, because of the enormous increase in the price of coal, the Prince decided to exploit the thermic energy of these "soffioni" on a much larger scale. But as other substances are emitted with the steam, among them sulphuric acid, which corrodes metals, particularly iron and therefore the pipes in which the steam was to be collected, he attempted to use this steam only for heating. Three turbine-alternators of 3000 kw. each were installed, fed by boilers at low pressure not heated by coal or other combustible fuel, but by the natural steam, superheated to 165 deg. C., issuing from these "soffioni" and piped and carried to the boilers.



Today the works at Larderello have a central plant of 16,000 hp., operating without interruption and distributing current to Florence, Livorno and Grosseto; the capacity is soon to be increased.

Here we have a new and original utilization of Italy's natural wealth; current is generated, not by the use of "white coal" (water power), but by means of heat energy of volcanic origin. As the natural steam available at Larderello and the surrounding country is, one might say, unlimited and depends upon the number of bore-holes made in the boraciferous soil, the great possibilities for further development are readily seen.



Why Should the Work of the Fuel Administration Cease?

By GEORGE H. SHEASLEY

> WASHINGTON, Feb. 1. The Fuel Administration today discontinued all price control and much of the supervision over distribution of coal, coke, oil and natural gas under an order signed by Administrator Garfield. With the passing of control over fuel, most of the activities of the Fuel Administration ceased. The Administration, however, under the Lever Act, cannot disband until peace has been declared. Some coal men said today that cessation of control over prices on coal would result in a lowering of prices. The unusually mild winter, it was said, also would tend to lower prices. Others predicted little change in price levels.

The press dispatch here quoted has a significant meaning.

The Fuel Administration is passing. Its much-criticized activities will, in all probability, soon have their existence in history only. Like many other war measures, the control of fuel ceases in the wake of the passing calamity which was the means of bringing it about. As indicated, the Fuel Administration must theoretically remain in existence under the Lever Act until peace is actually established. However, with the cessation of price control and the bulk of distribution supervision it is plain that the need for this branch of Government activity is past or rapidly passing and that its existence until the declaration of peace will be little felt by either the producer or the consumer of coal.

CONTROL OF PRICES HAS BENEFITED THE CONSUMER

The Fuel Administration, through its control of prices, undoubtedly has been the means of saving the consumer much money by preventing an abnormal jump in price which otherwise would have been almost certain to accompany the coal crisis during the winter 1917-18, and the more or less inadequate supply of the last year. By direct pressure brought to bear upon the consumer through the control of distribution and an educational campaign directed toward conservation, it has also been the means of saving enormous quantities of coal that would otherwise have been carelessly wasted, even in the face of the existing shortage. On the other hand, the Fuel Administration, hastily organized and handicapped by urgency of action in order to meet the emergency, undoubtedly has made mistakes that in some instances may have caused hardships that might have been avoided. In return for this it has probably been the object of more severe criticism than any other governmental department. But what man or group of men ever became associated with the initial attempt to remedy a serious situation, and actually remedied it, without making some mistakes, stepping on a number of uncovered or very thinly clad toes and receiving the usual amount of criticism as an additional reward for their efforts? The chief trouble with the average critic is that he does not see the true situation at all and, in turn, views the remedy applied only as it affects him individually, whereas the reformer must observe the situation in a collective light and adopt the desired remedy on the same basis.

Regardless of judgment that has been or may be passed on the efforts of the Fuel Administration, the fact remains that, in spite of possible mistakes, the carrying out of its conservation program has been the means of bringing about a huge fuel saving. The significant thing about the passing of the major portion of its activities is the indication that the fuel situation is rapidly approaching its normal condition. Its relinquishing control of prices is evidence that with the lull in industrial activity, the rapid improvement in transportation facilities and the effect of an unusually mild winter, a shortage no longer exists. Consequently, the law of supply and demand will now be able to take care of any desire on the part of the producer to boost selling prices and will probably cause their lowering before long.

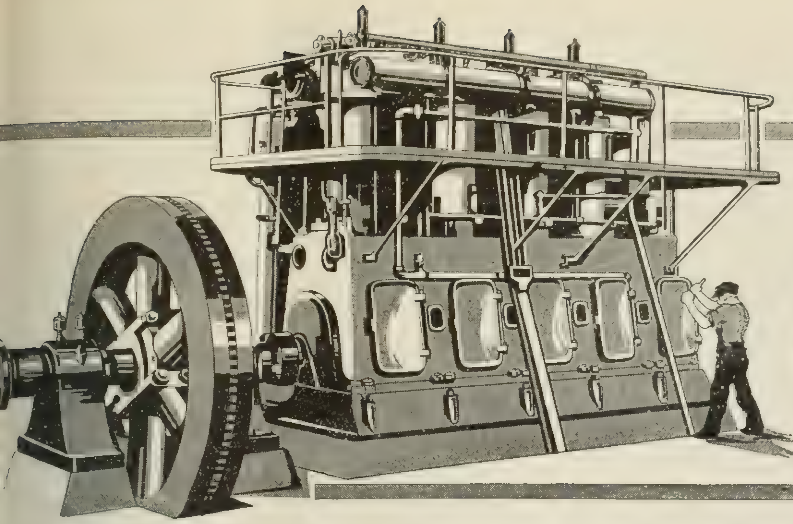
On the other hand, and for the same reason, the discontinuing of supervision over distribution indicates that there is no longer a necessity for restriction and compulsory conservation. Therefore the consumer, after having been protected from the producer and from himself as well for considerably over a year, is once more the sole master of his own coal pile and the manner in which it is used.

With the element of compulsion removed and the fuel situation further tempered by a gradual decline in price which is certain to accompany the return of normal market and transportation conditions, what will be the attitude of the industrial and the domestic consumer, but particularly the industrial consumer, toward the matter of conservation? The estimates of the Fuel Administration indicate that by the careful carrying out of its wartime conservation measures, a saving of one hundred million tons of coal per year is by no means a remote possibility. Thus the logical conclusion must be that under pre-war conditions this amount of coal was annually wasted, and a large portion of the waste is chargeable to industry.

CONSERVATION OR WASTE A MATTER OF PERSONAL CHOICE

Conservation or waste was a matter of choice with the consumer. Little action was taken toward the former and the latter was the result. The necessary steps for the forcible prevention of waste by the Government during peace may be unconstitutional, but the argument that this is the consumer's personal problem is unreasonable. The wasting of coal is not a personal matter, but the impoverishing of a national resource, and in industry the huge sums of money thus involved find their direct reflection in the price of the finished product. Therefore the matter of fuel waste is a national problem in peace no less than in war.

This being the case, why the cessation of this branch of Government control? If necessary during war—and no one will doubt that it was—the result accomplished will indicate that it is at least desirable during peace. Therefore, why not the adoption of necessary legislation to make the Fuel Administration, or a similar organization, a permanent governmental department?

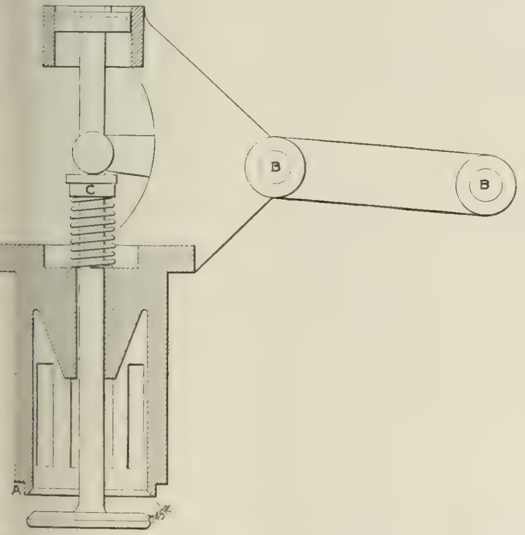


Talks on DIESEL Engines

by L. H. Morrison

IX—The construction of inlet and exhaust valves and their cages serves to occupy the minds of the men during an entire evening's talk.

NOW, boys," began Egan when they had gathered for their next talk, "the exhaust and inlet valves are pretty closely associated with cylder heads, so we'll consider valves next. I've found



IG. 1. INLET VALVE AND CAGE OF AMERICAN DIESEL ENGINE

at Woods here is a fair draftsman and he's going to ive us sketches of the valves we'll talk about." He rned to the young fellow, who stood at his elbow ushing self-consciously. Let's begin with your Fig. ," he said, and Woods sorted ut the sheet and handed it him. "This drawing," said R., "shows the inlet valve and cage of the original American Diesel. The valve is mounted on an extension at one side of the cylinder head, and the joint at *A* between the cage and the head is made tight by a copper gasket. Special attention should be given to this gasket. Quite a number of engines use copper gaskets on the valve cages, and they're a source of trouble. The average engineer is careless about getting the correct size—the gasket usually is cut too large on the outside. When the cage is inserted into the head cavity, the gasket binds, it's impossible to draw the bolts up snug, and as a consequence leaks occur around the cage. It's a good plan to always cut the copper gasket $\frac{1}{16}$ in. smaller, outside diameter, than the seat on which it to rest.

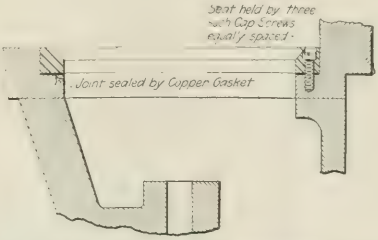

Seat held by three ...ch Cap Screws equally spaced.
Joint sealed by Copper Gasket

FIG. 2. FALSE SEAT FOR EXHAUST VALVE

"In some of the other plants the chiefs purchase gaskets from the engine builder. Of course in this way they are always sure of getting the correct size, but usually the price paid is quite out of proportion to this advantage. Here at the plant we originally made all the gaskets out of sheet copper, cutting them as required. In making a gasket as large as a valve-cage gasket we always kept the center cut out instead of throwing it away. We found that ordinarily a couple of small gaskets could be cut from this waste stock. This served to keep down our gasket expense. The last two or three years we have inclined toward the exclusive use of copper wire for valve-cage gaskets as well as cylinder-head gaskets. These are bent around a wooden form and the two ends are soldered together with a

At the next meeting Egan will explain how to determine when a valve needs regrinding, how to perform that operation and how to time the action of the inlet and exhaust valves

very soft solder. This is one of my own pet ideas, and for that reason I may be unduly partial, but it's my candid opinion that these wire gaskets are superior to any other.

"Adjustments are the things an engineer is mighty interested in. With a cage of this type the wear occurs on the pins *B* and the admission spring nut *C*. If the pins wear flat all that is necessary is to ream out the holes to a larger size and turn up new pins. This should not be required oftener than once in five years. The valve nut is a bad customer. The movement of the lever in opening the valve causes the threads on the nut to gradually shear off It's an expensive job to secure a new valve and nut; the cheapest method is to drill a ½-in. hole through the valve stem and the nut. By inserting a bolt with a drive fit, the nut can be locked firmly in place. I've tried spotting the stem and using a setscrew in the nut, but the hammer blow of the lever soon loosens the setscrew.

"The valve and the stem are made in one piece, of steel, and the valve seat is at a 45-degree angle. Frequently the valve stem wears out while the valve itself is in good condition. I've often cut off the stem and welded a new one on the valve."

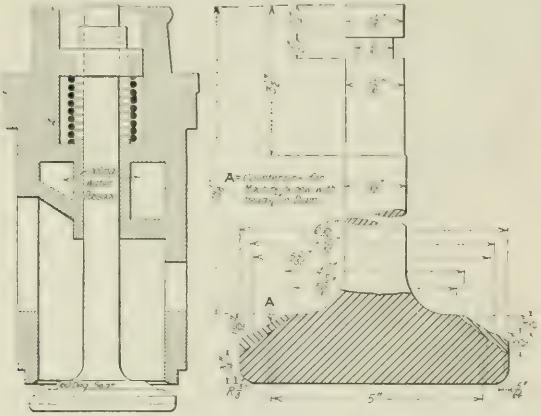


FIG. 3 FIG. 4

FIGS. 3 AND 4. VALVE OF McINTOSH AND SEYMOUR ENGINE

Fig. 3—Exhaust valve and cage. Fig. 4—Details of valve

"Chief, why doesn't the exhaust valve have a cage, too?" asked Woods.

"That, I presume, is merely a matter of choice on the part of the designer. Quite a number of engine builders use an elaborate inlet-valve cage, but, when they get to the exhaust valve, seem to be content with making the seat on the cast-iron head itself. If there is any advantage in an inlet cage, then surely the exhaust valve needs it all the more. The hot gases pass over the exhaust-valve seat, and it is natural that it corrodes faster than the inlet-valve seat. It requires grinding oftener, and, if the engine is old, the seat generally has been reamed so often as to make it worthless. We find false seats inserted just as in the case of our old American."

"How can you insert a false seat?" one of the men wanted to know.

"The next time you look into the engine, observe the way we did it. However, this sketch, Fig. 2, will show how it is done. It is necessary to bore out the seat and leave a square-shouldered recess. Then turn up your new seat out of tool steel and drill for three filister-head screws, as I show. You'll find it a job to tap the screw holes in the head, but it can be done if you are careful. When putting in this seat, always use a thin copper gasket to seal the joint. If a better job is desired, you can use an oxyacetylene flame and build up a new seat. This seat, after being reamed and ground, is just as good as the original. Both of these methods can be used on any engine where no exhaust-valve cage is used.

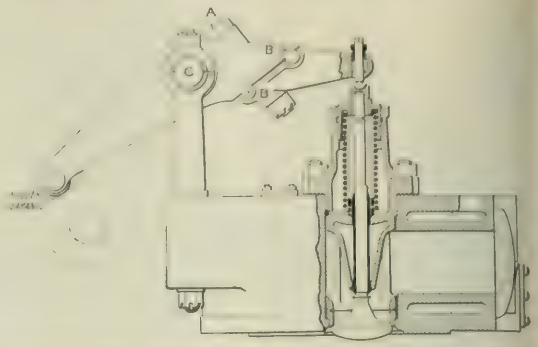


FIG. 5. EXHAUST VALVE OF BUSCH-SULZER ENGINE

"Let us go on to Woods's next drawing, Fig. 3, which shows the exhaust valve and cage used on the McIntosh & Seymour vertical engine. You will notice that the cage is partly water-cooled. While the inlet-valve cage is not so cooled, its dimensions are the same, and the two are interchangeable. In fact, at one of our plants water cooling is cut out, and the cages are used with either valve. In this way only one spare cage need be carried on hand. This cage is sealed by a gasket and is about as neat a design as I've met with.

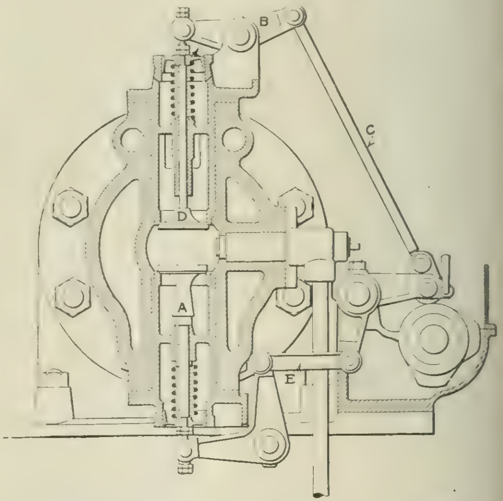


FIG. 6. VALVE GEAR OF McEWEN ENGINE

"Now the exhaust and inlet valves are identical in all respects save one. This difference is the valve seat, which, in the exhaust valve, is a separate part, as Fig. 4 shows. The inlet valve, on the contrary, is in one piece.

The seat on the exhaust valve is a steel shell fastened to the valve body by two countersunk machine screws. As you know, the hot exhaust gases pit the seat and I'll wager we regrind the exhaust valve three times to one regrinding of the inlet valve. With this design, when the seat is badly worn, all we need to do is to replace it."

"J. R., why are the valve seats at a different angle from the other engines here?" Woods inquired.

"The valve-seat angle on these engines is 60 deg. while on the Busch-Sulzer and the American the angle is 45 deg. This is merely a matter of designer's fancy, and as far as I can see, the angle does not affect the tightness of the valve. I believe it's easier to regrind the 45-deg. seat, but I'll confess this probably is merely a hobby of mine without foundation in fact."

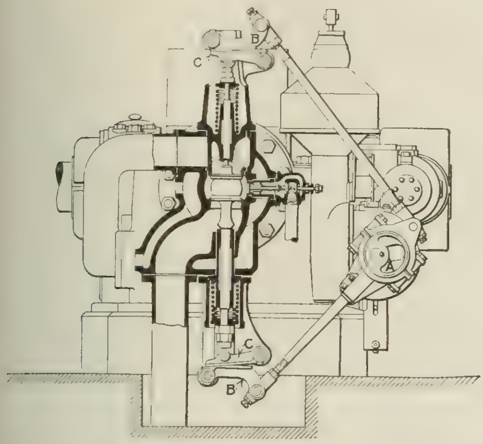


FIG. 7. VALVE GEAR OF ALLIS-CHALMERS ENGINE

Woods broke in: "Mr. Egan, this cage is like the Busch-Sulzer."

"Yes, it's very much like the Busch; so much so that it was hardly necessary for you to show the latter, as you have done in your Fig. 5. There are four studs holding the cage on the Busch while the other has two lugs. With two lugs it is easier to pull the cage to a perfect seat in the head—at least I have found it so. There is also a difference in the designs of the valve rocker-arms. The McIntosh & Seymour arm is made solid, but the Busch-Sulzer is in two pieces that are held together by a bolt *A*. To make the parts come together in their correct positions, the builders use two dowel pins *B* that rest in reamed recesses at the joint."

"Chief, what's the idea of the arm being made in two pieces?" Kelly asked. "It surely isn't due to trouble in casting the arm."

"The idea is to allow the cage to be removed without removing the whole rocker-arm. You see, since the rocker-arms are mounted on a common shaft *C*, it's necessary to remove the whole rocker assembly to get at a single cage. With the split rocker, only that particular rocker need be unbolted. It is an advantage, and we have never had any trouble in putting the halves together.

"Now, coming to horizontal engines, Fig. 6 shows a cross-section through the valve cages of the McEwen engine. The valves are made separate from the stems, and the exhaust valve has a skirt *A* carried down along the stem to deflect the exhaust gases and protect the stem against being burned out. The rocker-arm *B* is fulcrumed on a bracket cast with the valve cage. The reach rod *C* is fairly long and is in compression when the inlet valve *D* is being opened. On the other hand, the exhaust rod *E* is in tension."

He picked up the sketch shown in Fig. 7 and smoothed it out on the table.

"This is a section of the Allis-Chalmers engine," he explained. "The valves are moved by eccentrics *A* instead of cams, as in the preceding cases. To get a quick opening of the valves, the lever *B* is made with a cam surface that rolls against the face of the swinging tappet *C* that rests against the valve stem. The advantage is that there is no sharp blow when the valve is opened, such as you'd get with a cam striking a roller. The disadvantage is that there are more parts."

"How about grinding valves?" inquired Sandy the Scot, rolling his r's.

Egan glanced at his watch before he replied to the question.

"It's too late to begin that," he said, "for it's a long story. We'll continue it in our next, as the magazines say."

Testing Power Equipment

In a case lately before the District of Columbia Supreme Court (47 Appeal Cases, 147), a suit involving the right of a buyer of soot blowers, used in cleaning boiler tubes, to rescind the purchase on the ground that the equipment failed to do the work it was intended to do, that court laid down the following rules governing cases of this kind:

When machinery is bought on condition that, if at the expiration of a specified test period it proves to be unsatisfactory, it is to be returned at the seller's expense, the buyer is bound for the price unless he gives the machinery a fair test. But he is not bound to continue the test the full period if in a shorter time the machinery is found to be unsatisfactory.

A test period of this character runs from the time that the equipment is properly placed in position to do the intended work.

Where no time is fixed for the return of goods sold subject to the satisfaction of the buyer, they must be returned, or an offer be made to return them, within a reasonable time. A request by the buyer for shipping instructions is sufficient as an offer to return.

Generally speaking, an engine with small clearance space is supposed to be more economical than one with large clearance. It is not so much the clearance space as it is, the clearance surface that affects the economy. If there is a large amount of cooling surface for the steam to come in contact with when it enters the cylinders, there will be a great deal of condensation and more steam will be required. If the valves are placed close to the head of the cylinder, as in the Corliss engine, reducing the surface of the ports and passages and leaving only the cylinder heads and piston and a small section of the cylinder walls to condense the steam, a high degree of economy should be effected.

Calculation of Plant Efficiencies and Fuel Costs

By J. T. FOSTER

Engineering Department, Public Service Electric Co., Newark, N. J.

The author presents two charts with which the engineer may readily determine the efficiency of the boilers, evaporation, and fuel cost per thousand pounds of steam or mills per kilowatt-hour. The charts are worth adding to one's loose-leaf notebook.

THE high price and shortage of fuel, together with the tendency for still higher prices, has made the engineer consider the necessity of using the cheaper grades of fuel and of making of a more thorough analysis of plant performance.

The question of boiler and grate performance has been covered in some detail in a previous article in *Power*, and in this article it is the writer's purpose to discuss over-all plant efficiency so that the relation between the various factors entering into the problem may be readily determined with fair accuracy.

Individual calculations showing the various relationships are far from complex, as will be seen from the formulas given, but the working up of any considerable amount of derived data makes the task irksome.

The charts, Figs. 1 and 2, materially simplify the problem of deriving quantities that cannot be obtained directly from the station log.

The formulas from which the following problem is worked out and upon which the charts are based, are as follows: Let

B = B.t.u. per pound of dry fuel;
E = Evaporation from and at 212 deg. F.;
W = Plant water rate, lb. per kw.-hr.;
F = Pound, dry fuel per kw.-hr.;
T = Thermal efficiency of plant, per cent.;
t = Combined efficiency of boiler and furnace;
970.4 = B.t.u. per lb. steam from and at 212 deg. F.;
3415 = B.t.u. in one kw.-hr.

Then

$$E = \frac{B \times t}{970.4} \qquad F = \frac{W}{E} \qquad T = \frac{3415}{B \times F}$$

Problem: Assume that a plant is using 14,000-B.t.u. coal, has a combined boiler and furnace efficiency of 80 per cent. and a plant water rate of 16 lb. per kw.-hr. Find the over-all plant efficiency, cost of steam per thousand pounds and the cost of fuel in mills per kw.-hr.

Solution: $E = \frac{14{,}000 \times 0.80}{970.4} = 11.5$ lb. steam per pound of fuel; $F = \frac{16}{11.5} = 1.39$ lb. fuel per kw.-hr.; $T = \frac{3415}{14{,}000 \times 1.39} = 17.6$ per cent. plant efficiency. With fuel at \$4.50 per ton, the cost of the fuel item per kilowatt-hour would be $\frac{4500}{2240} \times 1.39 = 2.79$ mills. The cost of steam per thousand pounds would be $\frac{2.79 \times 1000}{16} = 17.5$ cents.

Where a number of such problems are to be worked out, or when it is desired to compare the values of coals of various prices and heat contents on a cost per kilowatt-hour basis the use of curves is much more convenient.

Fig. 1 is a quadrant chart from which may be obtained the evaporation per pound of fuel, pounds of fuel per kilowatt-hour and plant efficiency when the heat content of the fuel, combined boiler efficiency and plant water rate are shown.

Fig. 2 is worked out to show the cost of steam per thousand pounds and the cost of fuel per kilowatt-hour, in mills when the heat content of the fuel, combined efficiency and cost of coal are known. The use of the curves may be illustrated by the solution of the following problems:

Problem 1: Assume the same conditions as shown previously when formulas were used; namely, 14,000-B.t.u. coal at \$4.50 per ton, combined boiler and furnace efficiency 80 per cent., plant water rate 16 lb. per kw.-hr. Find evaporation per pound of fuel, pounds of fuel per kilowatt-hour, plant efficiency, cost of steam per thousand pounds and cost of fuel per kilowatt-hour.

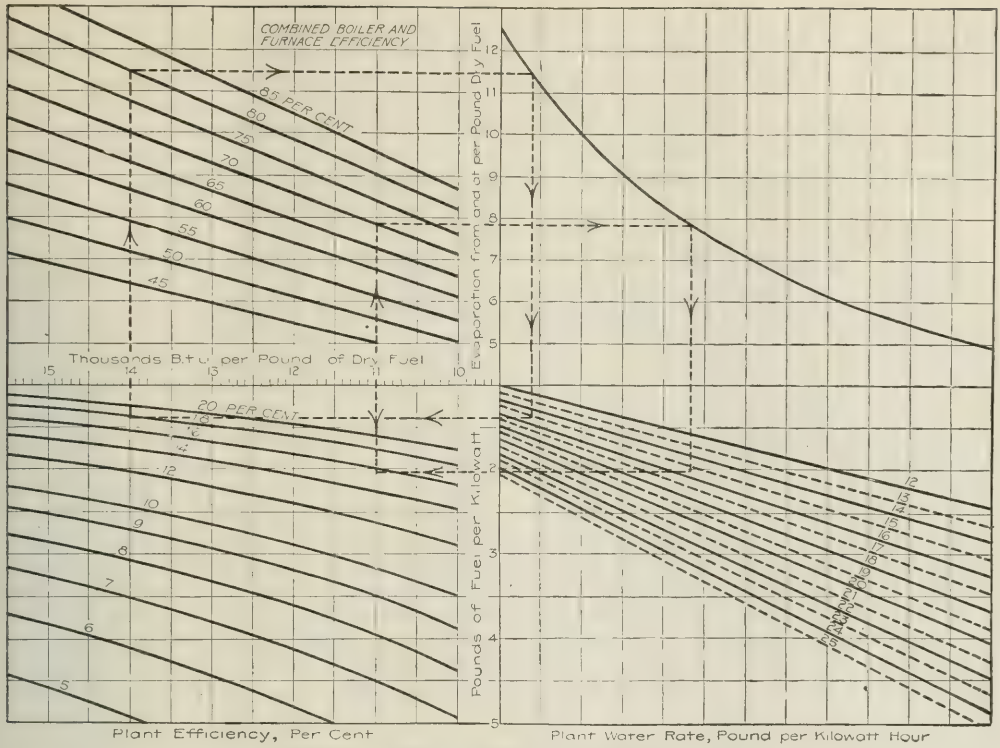
Solution: Fig. 1; from the 14,000-B.t.u. point project upward to the 80 per cent. efficiency line, then horizontally and read if desired the equivalent evaporation as 11.5 lb. steam per pound of fuel. Continue horizontally to the transfer curve and then downward to the 16-lb. water-rate line. Project horizontally to the left to the vertical scale and read 1.40 lb. of fuel per kilowatt-hour; continue horizontally to the line passing through the original 14,000-B.t.u. line and read the plant efficiency as 17.6 per cent.

Fig. 2; from the 14,000-B.t.u. line project upward as before to the 80 per cent. efficiency line, horizontally to the transfer curve, then downward to the \$4.50 coal line. Project horizontally to the left and read on the vertical scale, cost of steam as 17.5c. per thousand pounds; continue horizontally to the 16-lb. water rate line, then vertically downward to the scale and read cost of fuel as 2.79 mills per kilowatt-hour.

Problem 2: The plant assumed is using 14,000-B.t.u. coal at \$4.50 per ton, but has a chance to buy 11,000-B.t.u. coal at \$2.50 per ton. Would it be advisable to purchase the poorer coal and what would be the maximum price that could possibly be paid for this grade of fuel and still maintain a fuel cost of 2.79 mills as at present?

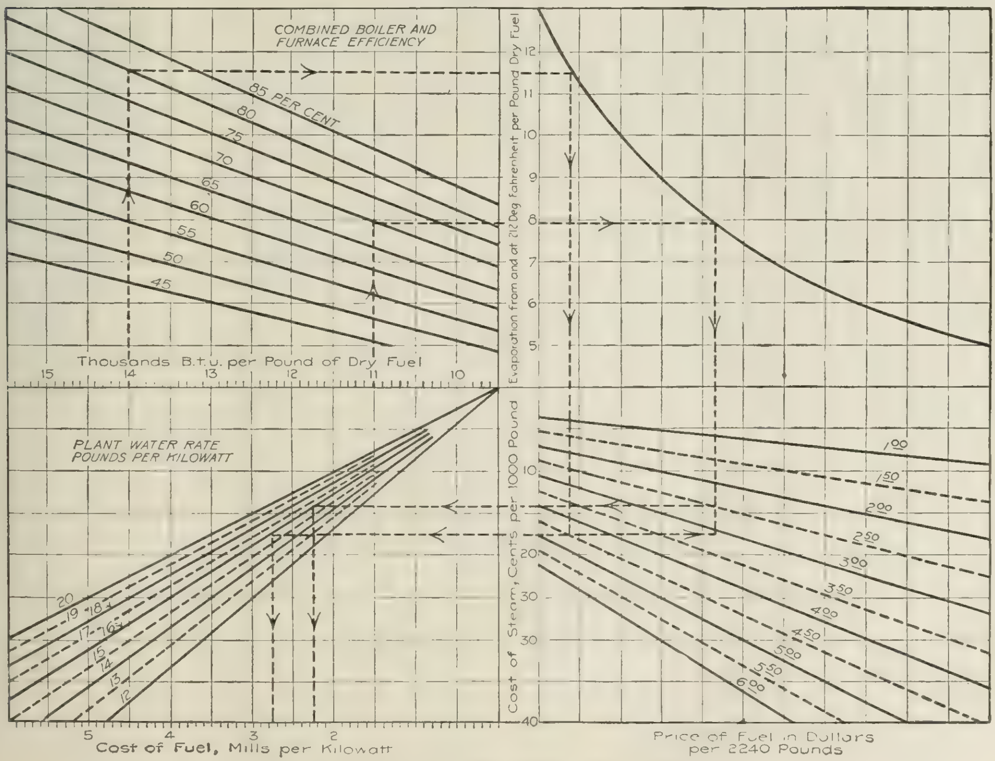
Solution: Performance tests on the 11,000-B.t.u. coal show that the boiler and furnace can develop an efficiency of only 70 per cent. as against the 80 per cent. that now obtains. Use the charts as described and read equivalent evaporation as 8 lb. steam per pound coal, cost of steam 14c. per thousand pounds; cost of fuel as 2.25 mills per kw.-hr. This compares with a present cost of 2.79 mills in the case of the 14,000-B.t.u. coal and is advantageous.

To obtain the maximum price that could be paid for the 11,000-B.t.u. coal, continue downward from the point on the \$2.50 line to the intersection of a hori-



POWER PLANT THERMAL EFFICIENCY

FIG. 1



POWER PLANT FUEL COST PER KILOWATT

FIG. 2

CHARTS FOR DETERMINATION OF PLANT EFFICIENCY AND FUEL COSTS zontal line corresponding to a cost of 2.79 mills and 15 lb. water rate and read maximum cost of 11,000-B.t.u. coal as $3.10.

From the operating engineer's point of view the following problem will be of somewhat more interest. Given a plant with a water rate of 18 lb. per kw.-hr., coal consumption 3 lb. per kw.-hr. and coal of 11,000-B.t.u. content at $1.50 per long ton. Find the evaporation, combined boiler and furnace efficiency, over-all plant efficiency, cost of steam and cost of fuel per kilowatt-hour. The evaporation will be = 6 lb. steam per pound of coal. With this data the following quantities may be read from the curves: Combined efficiency = 53 per cent., over-all plant efficiency = 10.5 per cent.; cost of steam per thousand lb. = 11.5c.; cost of coal per kilowatt-hour = 2.05 mills.

The Electrical Study Course—Adjustment of Voltage or Balancer Sets

Shows how the voltages of the balancer machines are affected by unbalancing of the load and describes methods of overcoming changes of voltages due to this cause.

THE balancer sets illustrated in the preceding lesson had the field coils of the two machines connected in series across the outside supply wires, as shown in Fig. 1. Unless the field coils and magnetic systems of the machines were absolutely identical, such an arrangement would not be found practicable, as there would be no way of adjusting the individual voltages of the machines if they proved to differ slightly; any change in the field current of one would mean a like change in that of the other, causing the voltage of the machines to change in unison.

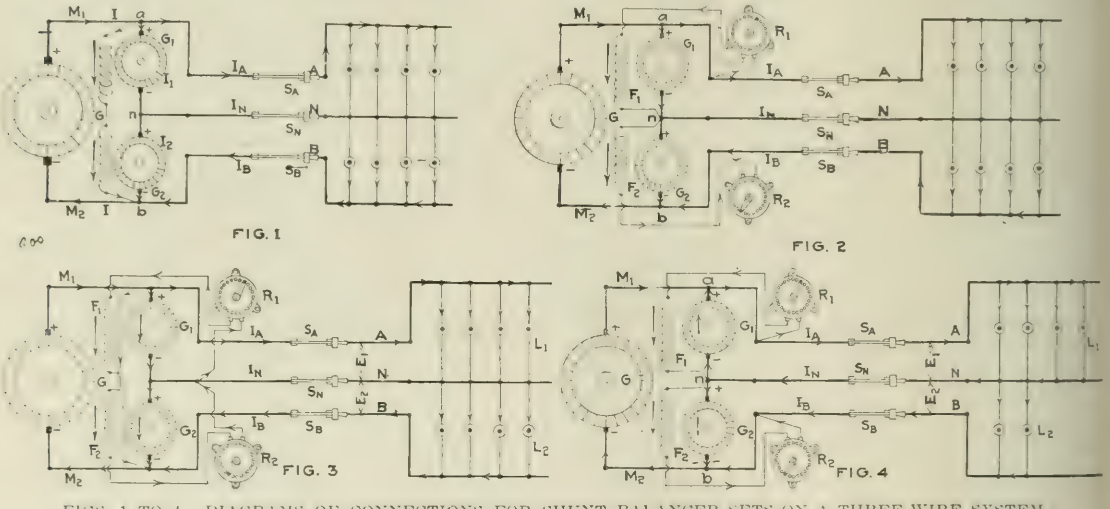


FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIGS. 1 TO 4. DIAGRAMS OF CONNECTIONS FOR SHUNT BALANCER SETS ON A THREE-WIRE SYSTEM

To provide the requisite amount of adjustment, the fields would have to be connected in some such manner as Fig. 2, in which each field is connected across its own machine in series with a rheostat.

The field current of one machine can now be changed without affecting that of the other, and consequently the two voltages can be regulated independently of each other. This connection has objections which are overcome by connecting the field winding of machine G_1 across the terminals of G_2 and the field of G_2 across the terminals of G_1, as shown in Fig. 3. The reasons for the unsatisfactory results obtained with the former method and the manner in which these drawbacks are avoided by the latter will be made clear in what follows.

In the preceding lesson it was shown that, when a three-wire system, such as that in Fig. 1, carried an unbalanced load, the voltage across the more heavily loaded side would be less than the voltage across the more lightly loaded one. This effect is considerably more accentuated when the connections are those of Fig. 2, since the decrease or increase in voltage across the lines affects the field current. For example, let us suppose that while no lamps are turned on the voltages of machines G_1 and G_2 have been adjusted by means of their field rheostats R_1 and R_2 until they are both the same, and that load is then put on the system in such a way that more lamps are turned on between *A* and *N* than are turned on between *N* and *B*, as in Fig. 4. The voltage across *AN* will thereby be caused to decrease while that across *NB* increases. That is, the voltage across *an* decreases and that across *nb* increases, and consequently the current through the field winding F_1 will be decreased while that through F_2 will be increased. The voltage of G_1 will therefore suffer a still further decrease, just as in the case of any self-excited shunt generator, while the counter-voltage of G_2, which is running as a motor, is increased.

When the field currents of the machines are the same, the generated voltage of the generator and the counter-electromotive force of the motor are nearly equal. Also the terminal voltage of the generator is its generated voltage minus the voltage drop due to its armature resistance, the same as in any generator supplying a load; while the terminal voltage of the motor is its counter-electromotive force plus its voltage drop, in the armature, which is true for any motor. But in the case under consideration—namely, that of Fig. 2—it has just been shown that the generated voltage of the generator and counter-electromotive force of the motor no longer remain equal when the load on the system is unbalanced due to the field currents in F_1 and F_2 not being equal. This makes the difference between E_1 and E_2 considerably greater than if the generated voltages of both machines were the same.

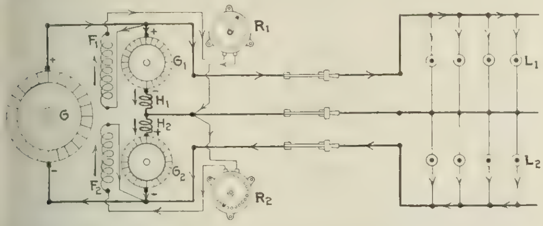


FIG. 5. COMPOUND-WOUND BALANCER SET CONNECTED TO BALANCED LOAD

The difference in voltage between E_1 and E_2 would of course depend on the difference in the loads on the two sides of the system. It would never be very great even for a considerably unbalanced condition, but a fluctuation of even a few volts is objectionable in the case of a lighting load. A very simple way to overcome the difficulty is, as already stated, to connect the field winding of G_1 to the armature terminals of G_2, and vice versa as in Fig. 3. In this case a drop in voltage across G_1 will decrease the current through F_2 and consequently reduce the generated voltage, in this case the counter-electromotive force of G_2, and an increase in voltage across G_1 will have the opposite effect. Similarly, a change in voltage across G_2 will affect the current through F_1 and hence the generated voltage of G_1.

As an illustration, let us suppose that the loads L_1 and L_2, Fig. 3, are balanced and that the voltages of G_1 and G_2 have been adjusted to the same value by means of the field rheostats R_1 and R_2, under which condition the generated voltages or counter-electromotive force E will be the same in both machines. Now assume that load L_1 is increased or L_2 decreased; then, as already explained, G_1 will operate as a generator and G_2 as a motor. The terminal voltage E_1 of G_1 will therefore tend to decrease and the terminal voltage E_2 of G_2 will tend to increase. However, as soon as E_1 begins to decrease, the current through F_2 decreases and consequently the counter-electromotive force E of G_2 becomes less, thereby causing E_2 to be smaller than it would be if E remained the same. Also, as soon as E_2 begins to increase, the current through F_1 also increases, and hence the generated voltage E of G_1 increases. The value of E_1 will therefore be greater than it would be if E had remained the same in both machines.

From these facts it is evident that the result of connecting the field windings as in Fig. 3 is precisely the opposite of that obtained when they are connected as in Fig. 4; that is, that while in the latter case the difference in the voltages E_1 and E_2 occasioned by an unbalancing of the load is accentuated as compared with the conditions of Fig. 1, it is actually diminished in the former case. The operation of the balancer set is therefore much more satisfactory when the connections of Fig. 3 are used.

Another method of stabilizing the voltages across the two sides of the balancer set is to use compound-wound instead of shunt-wound machines. The connections would then be made as shown in Figs. 5 and 6. From the connections in Fig. 5 it is seen that when the load is balanced, the two machines of the balancer set are operating as differentially connected compound motors; that is, the shunt-field ampere-turns oppose those of the series-field winding. When the load is unbalanced, as in Fig. 6, in the machine that acts as a generator (in this case G_1) the currents in the two field windings have the same direction, but the motor fields remained in opposition. The latter condition tends to increase the speed of the motor and with it the speed of the generator, which, if the field strength of the generator remained constant, would cause the voltage to increase across the terminals of G_1. However, the series-field winding is assisting the shunt field, therefore as the load is increased the voltage of G_1 will also be increased. Hence the voltage of G_1 will be increased from two sources, one the tendency of the machines to increase in speed and also due to the generator field increasing in value from the compounding effect of the series winding. The effect of compounding is therefore similar to that found when the fields of shunt machines are interchanged, in that the unbalancing of the load causes the generated voltage of the generator to increase and the counter-electromotive force of the motor to decrease, thereby causing the terminal voltages E_1 and E_2 to remain practically constant irrespective of the degree of unbalancing.

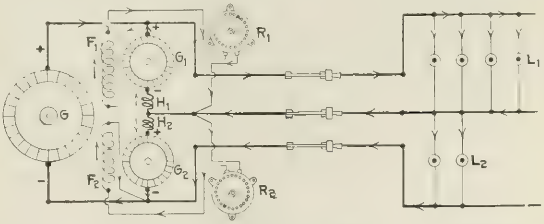


FIG. 6. COMPOUND-WOUND BALANCER SET CONNECTED TO UNBALANCED LOAD

So far we have only considered whether G_1 was running as a generator and G_2 as a motor, or vice versa, without investigating very closely the value of the current delivered and taken by each, and without reference to the exact effect on the speed of the set. We will now take up these points in the order mentioned.

Since the arrangement of Fig. 1 is simpler than that of any of the others, we will make use of it in the discussion of current distribution. It is, however, to be understood that the argument applies equally to any of the other methods of connection. When the system is balanced, we have a generator G supplying current to a number of lamps and to two motors G_1 and G_2 connected in series. When the system is unbalanced, we have G operating as a generator, and also one of the machines G_1 or G_2 operating as such, being driven by the other, which continues to run as a motor under increased load. However, G must furnish all the power used in the system since it is the only machine that is connected to a prime mover, such as an engine or turbine. Whatever current is taken by G_1 or G_2 running as a motor to drive its mate as a generator must be supplied from G, since there is no other source of power.

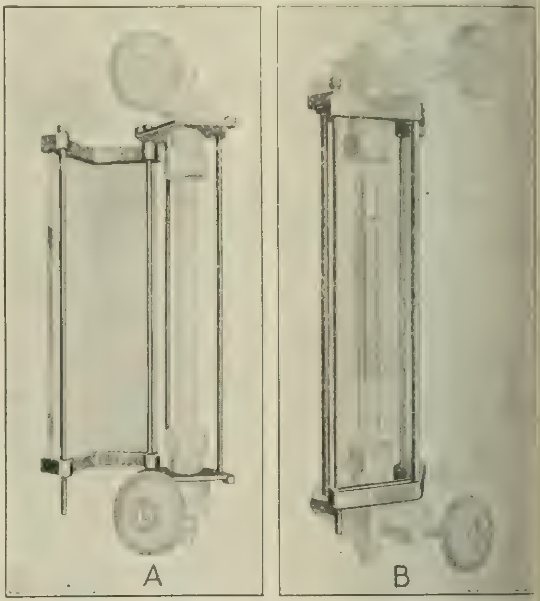
When the load is balanced, there will be no current in N and the currents I_1 and I_2 through G_1 and G_2 will be the same. The current in the mains M_1 and M_2 will therefore be the sum of the current I_1 or I_2 and the current I^A or I_B of the outside wires; that is, $I = I_1 + I_A = I_2 + I_B$. When the load is unbalanced I_A is no longer equal to I_B and hence a current I_N flows in the neutral. The current I in M_1 must of course be equal to I in M_2 in any case, so that the differences between I_A, I_B and I_N must be taken care of by the balancer set. Just how the currents are distributed will be taken up in the next lesson.

In the problem of the preceding lesson it was required to find the current in the three lines of a 115-230-volt three-wire system that has thirty-two 20-watt lamps connected across one side and twenty-four across the other; also to find the current in the outside wires and the voltages across the two sides of the system if the neutral wire were to become open-circuited. The current taken by each lamp would be its input divided by the voltage, or $\frac{20}{115} = 0.174$ ampere. The load across one side would therefore be $32 \times 0.174 = 5.57$ amperes, and that across the other $24 \times 0.174 = 4.18$ amperes. The former would be the current through one of the outside wires and the latter that through the other, while the current through the neutral would be their difference, or $5.57 - 4.18 = 1.39$ ampere. If the neutral were to be opened the current would be found by dividing the outside voltage—namely, 230 volts—by the total resistance connected between the outside wires, which would be the sum of the resistances across the two sides. Since each lamp takes 0.174 ampere, its resistance must be $\frac{115}{0.174} = 661$ ohms. Consequently, the resistance across one side of the system will be $\frac{661}{32} = 20.7$ ohms and that across the other $\frac{661}{24} = 27.6$ ohms, making the total $20.7 + 27.6 = 48.3$ ohms. The current in the outside wires will therefore be $\frac{230}{48.3} = 4.76$ amperes. The voltage across each side will be the current times the resistance, which gives $4.76 \times 20.7 = 99$ volts across one side and $4.76 \times 27.6 = 131$ volts across the other.

The distance between the generator G and the balancer set in Fig. 1 is ½ mile. If the maximum load to be supplied is 100 amperes at 110 volts and the drop in the mains M_1 and M_2 is not to exceed 10 per cent., neglecting the losses in the balancer set, what size wire would have to be used in the mains M_1 and M_2?

Durabla Gage-Glass Shield

A new gage-glass shield possessing desirable features of safety and unobstructed view has been developed recently by the Durabla Manufacturing Co., 114-118 Liberty St., New York City. The device consists essentially of two laminated glasses set in cast retainers, forming a V-shaped protector over the front of the gage-glass. The shield is hinged to the water gage and can be swung freely to either side when it is desired to insert a new gage-glass. The closed and open positions of the shield are shown at A and B respectively. The protecting plates are made up of laminated glass ⅜ in. thick and 2½ in. wide, the length varying to meet the requirements of the gage to which they are applied. The plates consist of three independent layers of glass with a transparent compound between. It is said that they will withstand the bursting of the gage-glass or a heavy blow from boiler-room tools. Even if the exterior layers are cracked or checkered, the plate as a whole stands up and the individual particles are held in place by the compound so that there are no flying glass or splinters to injure the attendant. When the gage-glass breaks, the outflowing steam is directed backward and away from the operator coming to repair the damage.



OPENED AND CLOSED POSITIONS OF SHIELD

All metal parts are of brass so that they will not rust or corrode, but will retain their original pleasing appearance. The vertical members of the protector are brass rods of small diameter. From either side there is no obstruction of the view, and even when directly in front of the gage the water level is still visible, the small rod at the apex of the V being only one-third the diameter of the gage-glass.

The design of the shield had four objects in view: Safety to the attendant, protection of the glass from mechanical breakage and cold drafts, unobstructed view and simple application.

Geyser Boiler Cleaner

Keeping boilers clean is an important step in obtaining efficient operation of the plant. If a boiler's sheets are kept free from mud and scale, not only is the heat given off by the burning fuel more rapidly absorbed by the water in the boiler, but the plates are prevented from overheating. Cooling down and washing out of boilers at frequent intervals is to be avoided where possible, but such practice is necessary where muddy water is used or water containing scale-forming salts.

For the purpose of removing the deposits from the feed water a steam-boiler cleaner, for use with Scotch marine boilers, known as the Geyser, is manufactured by the Geyser Boiler Appliance Co., Detroit, Mich. This apparatus is simple in construction, and its application to a boiler is shown in Fig. 1. The system consists of a number of collecting nozzles attached to pipes so as to distribute them along the bottom of the boiler shell. See Fig. 1. These nozzles are piped to a valve chamber, Fig. 2, that is provided with three ports, one on each side and one at the top.

When raising steam in a Scotch-marine boiler, heat is imparted to all of the water above the grate line, which consequently soon acquires a high temperature. The valve chamber of the cleaner being placed in the top of the boiler, to which is fitted the conductor pipes, soon absorbs heat from the surrounding water, and this heat is conducted to the water contained in the chamber, with the result that it starts to expand in volume, and its specific gravity changing, it soon finds its way out of the discharge port in the top of the valve chamber, and is replaced by the water in the conductor pipe, which leads to the bottom of the boiler. Thus there is a continual circulation in the system as long as there is a difference in temperature between the bottom and the top of the boiler, unless the valve closure is effected. The method of operation is as follows:

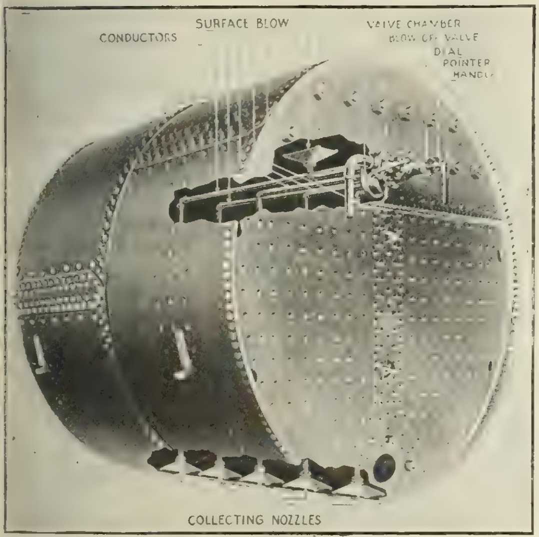


FIG. 1. APPLICATION OF THE CLEANER TO A SCOTCH BOILER

To start the circulation, open the main blowoff valve and turn the handle on the valve shaft until the pointer is even with, say, No. 1 on the dial plate. This opens communication between No. 1 collecting nozzle and the main blowoff pipe. The pressure of the boiler and the shape of the collecting nozzle produce a rapid current around and into the collector nozzle, for an area approximately six inches on each side of the nozzle. When all sediment and small pieces of scale are removed from this part of the boiler, the handle is turned until the pointer is even with the next number on the dial. The pointer is allowed to remain in this position until all solids are removed, and then the operation is repeated by moving the valve until a complete revolution is made. In this way sediment and scale-forming ingredients are removed from the bottom of the boiler and blown out through the blowoff pipe.

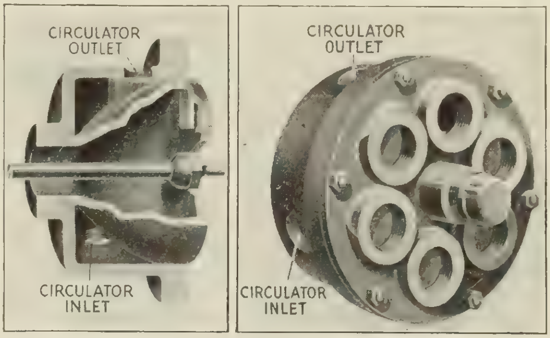


FIG. 2. SECTIONAL AND END VIEWS OF VALVE CHAMBER

Injury in Using Steam

The plaintiff, an employee in a manufacturing establishment, was directed by his superior to clean out some empty barrels in which cylinder oil had been contained. Following the directions given him, he inserted a steam flue blower in a hole in one of the barrels, permitting steam to escape from the same hole. The barrel exploded, blowing a piece of pipe through plaintiff's hip.

In an action to recover damages from the employer on account of the accident (McLeod vs. Des Arc Oil Mill Co., 206 Southwestern Reporter, 655), the Arkansas Supreme Court holds that, although plaintiff had had considerable experience in handling steam and steam engines, still he was not debarred from recovering damages on a theory that his employer had negligently omitted to give him proper instructions as to how to steam the barrels, if he actually did not know what volume of steam could be safely used in the barrels. The law charges an employer with knowledge concerning the dangers incident to employment and the duty of instructing employees concerning such dangers as are likely to be unknown to the latter through inexperience.

It is not economical to operate an engine when it is overloaded or when it is too large for the work it has to do. Under such operating conditions the cutoff will probably be either too late or too early in the stroke for the economical use of the steam. If the cutoff is too early there will be an increased proportional loss from cylinder condensation, and if it is too late the expansion of the steam will not be so complete.

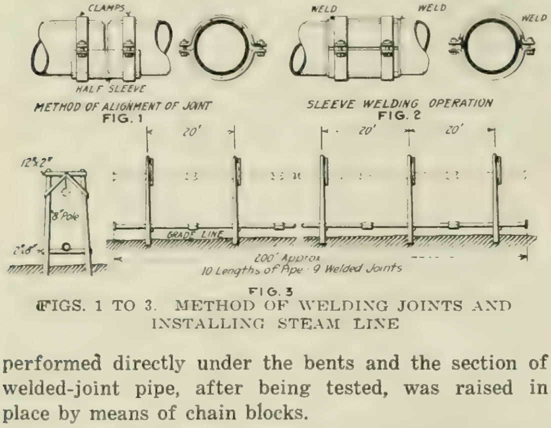
Electrically Welded Steam Lines*

BY H. R. WOODROW

Assistant Chief Electrical Engineer, New York Edison Co.

IN THE construction of the United States Government Explosives Plant "C" at Nitro, W. Va., something over ten miles of steam lines carrying 190 lb. pressure were required. Of this about five miles were 12 in. diameter or over. At the time the construction of this plant was undertaken, in the spring of 1918, the available supply of large extra-heavy flanges was very small and it was doubtful if a sufficient quantity could be obtained within the time available for completing the plant. Therefore in order to finish the work in time the Thomas E. Murray Engineering Corp., which was handling the power-section engineering work, recommended, and the War Department adopted, the use of arc welding for the connection of all the high-pressure steam and feed-water lines 6 in. in diameter and over in the plant. At the time the armistice was signed over one thousand of these joints had been completed and were in service.

All the outside mains are suspended from timber bents, at a height of approximately ten feet about the ground, as shown in Fig. 3. The welding operation was performed directly under the bents and the section of welded-joint pipe, after being tested, was raised in place by means of chain blocks.



FIGS. 1 TO 3. METHOD OF WELDING JOINTS AND INSTALLING STEAM LINE

The length of welded-joint pipe so handled averaged approximately 200 ft. and contained ten sections of mill-length pipe and nine welded joints, the two end sections having a standard Van Stone flange for connecting with fittings or valves in the completed line.

The type of welded joint used is a combination butt and sleeve joint, as indicated in Figs. 1 and 2. The butt ends of adjoining sections were scarfed off at an angle of about 45 deg. with the axis of the pipe and butt-welded. The weld was then chipped flush with the pipe surface, and a hydrostatic test of from 400 to 600 lb. was applied to the completed length. After inspection, the reinforcing sleeve was applied. The sleeves are made in halves and are die-formed of metal equal in thickness to, and of a length approximately equal in diameter to that of the pipe to which they are applied.

The welding was performed by the pencil-arc process, the current employed being 110-volt alternating, which was obtained primarily from the general supply system for the plant, carrying 6600-volt three-phase current led through transformers and secondary lines to the welding reactances, furnishing the controlling medium required for the welding operation.

The electrodes used in the butt-welding operation were slag-coated and were of the same character as those extensively used in ship welding. The welding of the sleeves was performed with a low-carbon steel bare wire. The butt weld consisted of two runs of metal, the first of No. 10 and the second of No. 8 wire, the first run being carefully cleaned free of slag, first by hammering and finally by scrubbing with a wire brush until the metal showed clean and bright before applying the second run. The sleeve weld consisted of two longitudinal welds joining the two halves of the sleeve, and a weld on each end of the sleeve completely joining the sleeve to the pipe (See Fig. 2).

The application of the sleeve was determined upon for structural reasons, as the stresses likely to be encountered in an installation of this character are practically indeterminate.

One of the problems met with in handling pipe in such long lengths is the question of accurate alignment, which was accomplished in this case in the following manner: The proper level above the ground for the pipe was determined by its accessibility to the welder, and this point was marked on each leg of each pipe-carrying bent, and timber joists were securely fastened between the legs of the bents at the proper level, as in Fig. 3. The pipe lengths, approximately 20 ft. long, were laid on these joists, and as the spacing of the bents along the axis of the pipe was 20 ft., this brought a joint between each pair of bents. The ends of the individual pipe lengths were then brought within about $\frac{1}{16}$ of an inch of contact and lined up and clamped securely in position by means of a half-sleeve applied to the under side of the pipe and fastened by straps to each end of each pipe section (See Fig. 1).

This left the upper half of the butt joint ready for the first run of the weld. When one-half of the first run was completed on each joint, the clamps and the sleeve were removed and the entire 200-ft. length of pipe was rolled on the joists until the other half of the butt joint was uppermost, and the first run was then completed. In consequence of the fact that it was possible to turn the pipe at will thereafter, the second run of the weld was made continuous.

It takes one welder about three hours to completely butt-weld and sleeve a 12-in. joint. The time required for other sizes would be in proportion to their diameter.

I feel that the use of the electric welding is going to be a very important feature in the development of power stations where the tendency is going to higher steam pressures, in the neighborhood of 600 lb., as welded joints can unquestionably be made stronger than any other connection and are absolutely leakproof.

No man who frets and chafes at his work can do justice to himself, his job or his employer.

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*Presented in the discussion on electric welding at a joint meeting of the American Institute of Electrical Engineers and the American Institute of Mining Engineers, held during the Midwinter Convention of the American Institute of Electrical Engineers, New York, N. Y., Feb. 19, 1919.

EDITORIALS

Interpole Direct-Current Machines

IN THE development of electrical apparatus during the last twenty years many changes in the design nd construction of direct-current machines have taken lace. If a typical modern direct-current motor of from ive to one hundred horsepower rating based on a cerain speed be compared with a machine of the same orsepower and speed rating, built fifteen or twenty ears ago, two points of difference will at once be pparent. First, the modern motor will be smaller than he old machine; and second, it will, in all probability, ave interpoles, whereas the old machine will not. The irst of these two points of difference is the effect, f which the second is, to a large extent, the cause. better understanding of the operating conditions of he machine and a better knowledge of the electric nd magnetic properties of the materials have enabled he manufacturer to make such economical use of his aterial as to reduce very considerably the quantity equired to make a machine that will accomplish a given esult. Of all the causes that have contributed toward his end, no one thing has had greater influence than he introduction of interpoles.

Commutation was formerly much more than at pres-nt the bugbear of direct-current machinery. By a ufficiently liberal use of materials in the noninterpole ype, good commutation at a certain speed was accom-lished. But it is not always desirable that a motor un at one speed only. By the use of an adjustable-peed motor such intermediate speed-changing devices s gears, belts, step pulleys, etc., may often be elimi-ated. The average noninterpole motor will usually run atisfactorily at any speed between one hundred and ne hundred and fifty per cent. of its rated revolutions er minute, but at higher speeds sparking at the brushes ecomes excessive. On the other hand, an interpole otor that is designed for that purpose will operate roperly at any speed between one hundred and four undred per cent. of its rated revolutions per minute.

Not only is it true that the range of speeds over hich a motor will operate satisfactorily is increased y the use of interpoles, but the range of loads is ncreased as well. When a noninterpole machine is perating at a certain load, as, for example, full rated ad, the commutating conditions may be ideal, but at ny other load they will not be ideal unless the brushes re shifted. With interpole machines the brush posiion that is best for one load is best for all loads.

There are certain things about interpole machines hich it is very desirable that the operating man who as direct-current machines in his charge should know. e should have sufficient knowledge of the theory of ommutation so that he will understand why interpoles re used; he should be able to tell whether the inter-oles in any of his machines are of the correct polarity nd whether the windings are properly connected; he should know that the brushes of an interpole machine, when once correctly set, should never be shifted, regardless of changes in load, speed or direction of rotation; he should know that an interpole motor should run at the same speed in either direction of rotation and that if it does not, the brushes are not set in the neutral position; and he should know the effect on the speed and stability of his motor when its interpoles are not of the proper strength and how to proceed to remedy the trouble. A careful study of the two articles on "Interpole in Direct-Current Machines," the first one of which appears on another page of this issue, will give him this knowledge.

Capacities of Large Steam Turbines

ELSEWHERE in this issue appears a paper on steam-turbine design, by J. F. Johnson, which our readers will appraise as a valuable as well as a bold piece of engineering literature. It is bold because of the frankness with which the author goes into detail about the experience in the operation of reaction turbines of thirty thousand kilowatts and greater.

Calling attention to the fact that turbines of fifteen thousand kilowatts capacity did not appear until about 1908, while today many large plants have turbines of thirty thousand kilowatts or greater capacity, he asks: "Has this growth been natural, logical and healthy, or has it suffered temporarily from overstimulation which is destined to result in a relapse, or reversion to smaller sizes?"

The growth has been logical, broadly speaking, if not as "healthy" as some would desire. While some engineers may state that the growth has not been natural, inferring that it is undesirable to go beyond a certain capacity, say thirty thousand kilowatts, consensus of opinion would indicate that this is not so and that there will not be a reversion to comparatively small sizes.

Of course one may get too many eggs in one basket. But when has one got too many? Because he has many it does not follow that he has too many. It has helped operating costs very materially to enlarge upon the unit capacities of prime movers and boilers. And who does not recall with what anxiety on the part of the profession generally the large Delray boilers were put in service? It was a daring thing to jump from the customary boiler of five hundred horsepower to one of nearly twenty-five hundred rated horsepower, providing it with stokers that made it possible to increase the rating to such length that a load of eleven thousand kilowatts could be carried by it. Boilers of fifteen hundred horsepower have become more widely used for large stations than those of the size used at Delray. But one cannot find an appreciable flaw in the reliability or performance of the latter. It is more a question of adaptability. The same may be said of the turbine. The larger the load demand at one time on the station the larger the capacity of the units installed in order to take advantage of low cost per unit of capacity. The large turbine has not only given more economical performance because of its size; but a material reduction in cost of foundations, buildings, piping and switching equipment results as compared with costs for the same output in machines of smaller capacities.

Mr. Johnson avoids consideration of the question of how far it may be advisable to go in the quest of great capacity in a single cylinder. But the question is as much a part of large steam-turbine design, application and service as stoker performance is a part of modern boiler practice. Naturally, the limit of capacity is sooner reached in a single-cylinder than in a multiple-cylinder machine. But what is that limit? Development up to date has reached forty-five thousand kilowatts in the single-cylinder turbine. Is this the limit, and if it is, why?

Electric Welding

THE possibilities of development under intensely concentrated investigation are remarkably illustrated in the progress that has been made in the application of electric welding under the tremendous stimulus created by the demands of the great war that is passing into history. The degree of importance that this use of electricity has reached is reflected in the fact that an entire afternoon session of the recent midwinter convention of the American Institute of Electrical Engineers was devoted to the subject.

Of the two methods of electric welding, arc and resistance, the former has undoubtedly undergone the greater improvement. That this should be so is quite natural, since the resistance method has for many years occupied a position of development relative to which that of the arc process might be called crude. In the research work done on the arc process it appears that the efforts have been concentrated more particularly on the type that uses a metal electrode as distinguished from the one using a carbon or graphite pencil. It was also brought out that practically all efforts had been concentrated upon the application of the process to steel welding. In fact, the great need for welding came in connection with the urgent demands of the shipbuilding program, and as a consequence a major part of the efforts of the committee under whose supervision the work was carried on, was directed toward the problem of applying the process to the needs of the steel-ship builder. However, the investigations undertaken let in a flood of light on the entire situation and points the way toward the eventual perfection of the process.

The work was begun under the auspices of the Standards Committee of the American Institute of Electrical Engineers, from which it was taken over by the General Engineering Committee of the Council of National Defense, which eventually carried on its work under the Emergency Fleet Corporation. The members of the committee are to be congratulated on the impartiality and conservatism that are reflected in its findings, which formed the basis of most of the papers presented.

That the subject is an extremely far-reaching one and that much research work is yet to be done is apparent upon considering the multitude of variables that enter into it. As in oxyacetylene welding, the chief variable is the operator, and this will probably always remain so in the case of welding that cannot be done automatically. Among the other variables are the composition of electrode used, the effect of bare versus covered electrodes, the current density used under different conditions, and the preparation of the work to be welded. There is also the choice, as in power applications, between direct current and alternating current, with advocates on each side, although the results obtained indicate that equally successful results, as regards the quality of welding, can be obtained whichever is used.

American Engineering Standards Committee

AMONG the many things the world war has taught us is that individual effort is uneconomical and costly, and if a nation is to meet the competition of the future successfully it must be through collective action, not only among industries but also among individuals. Before this collective effort can attain its greatest results, there must be a higher degree of standardization than in the past, at least within the nation itself. It is for this purpose that the American Engineering Standards Committee has recently been organized, the purpose and machinery of which were outlined by President Comfort A. Adams in his address, "Engineering and Industrial Standardization," before the midwinter convention of the American Institute of Electrical Engineers. The part of this address dealing with the American Standards Committee is published on page 337.

One of the first thoughts that must suggest itself to the reader, on reading this outline, is that the machinery of this committee is a masterpiece in American organization, comprehensive in its scope and democratic in its method of dealing with the work to be undertaken, embodying an appreciation that has been lacking in many of the standardization organizations of the past—as Mr. Adams has expressed it, "A realization that a standard must not only be rational and technically correct, but also acceptable to all those interested in its manufacture and use, and the mere promulgation of a standard by any society, however powerful, does not make it a real standard."

The work of this committee should receive the hearty support of every industry coming within its field of effort since its creation will apparently eliminate the overlapping and confusion of standards that our industries have been beset with by the many different standards committees of the numerous engineering and industrial organizations in this country today, and with the proper support and coöperation of all interested organizations, it should contribute largely to the industrial development of the nation.

Speaking of a Ford engine that was used to drive an ice-cutting machine, a reporter in one of our small-town newspapers says: "The engine went into the lake in twelve feet of water, but continued to run for about five minutes at the bottom of the lake." Fishy? Not a bit. It may have been a leftover from one of Henry's much talked of one-man submarines.

CORRESPONDENCE

Diagram Showed Lack of Oil

A new engine, when being "tuned up," seemed to be in difficulty, so I indicated it, obtaining the diagram shown. The valves were not closing properly, which seemed to show that the cylinder was not getting enough oil. After speeding up the lubrication and waiting a few minutes, a regular diagram was obtained. It was easy then to convince the attendants of the importance of watching the cylinder lubrication.

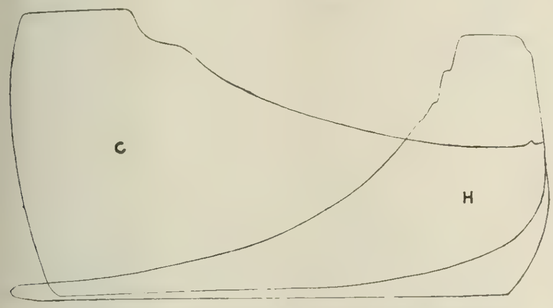


DIAGRAM FROM POORLY LUBRICATED ENGINE

Toronto, Ont., Canada. R. McLaren.

Care of Economizers

In the Feb. 11 issue of *Power*, page 192, was an article entitled "Care of Economizers," by J. F. Daggett, and as indicated by the subcaption, some very helpful information was set forth. However, there was one paragraph that I am unable to understand, or, at least, to understand the condition referred to.

Quoting from the article, "If the water in the economizer gets too low, immediately open the bypass flue damper, leaving the outlet wide open." The first clause of this sentence would seem to imply that under ordinary conditions a certain water level should be maintained, and the questions I would like to ask are, Where is the point of normal water level, and what means are provided to determine if the water is too low or too high in the economizer? The necessity of knowing this would seem apparent in view of Mr. Daggett's suggestion for immediate action. Does he mean that economizers are, or should be, fitted with water-glass and try-cocks? D. E. Granger.

Newark, N. J.

Gate Valve Exploded

Referring to the article on page 83, of the Jan. 21 issue, I would call attention to the fact that such things often happen. It is sometimes difficult to remove a nipple from a screwed end valve without damaging the thread in the valve or on the nipple to such an extent that neither can be used again.

It is seldom that two or three persons will put the thread on the nipple the same way, but assuming that the thread in the valve is all right, that on the pipe or nipple might be a little different, and to hold a thread end tight in a fitting a little white lead can be used; and naturally, after the joint has been in use for some time the thread is so tight that the nipple can be removed only with difficulty.

If a flanged gate valve had been used, such an experience as mentioned should not have occurred, because a pair of flanges could be easily loosened. Furthermore, if at any time a nipple is removed from a standard-size gate or globe valve, the valve is in most cases deformed and not good for further use.

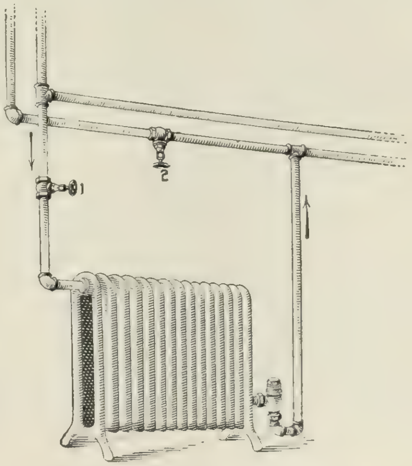
I do not agree with the argument of many engineers that so many flange connections are the causes of leaks, especially now that there are on the market many good gaskets which will answer the purpose.

In the long run it is much cheaper to use flanged fittings around the whole plant. F. C. Heylman.

Martinez, Calif.

Radiators Located Below Vacuum Return Main

It is sometimes desired to heat a basement or cellar room where the steam and return piping is overhead and ceiling coils are objectionable. In this case a hot-water type radiator can be used to advantage by installing it so the drip of a return riser circulates through it in the same manner as a hot-water radiator, as shown in the illustration. To operate, open valve 1 and close or partly close valve 2, and the hot water will then pass through the radiator and give off heat.

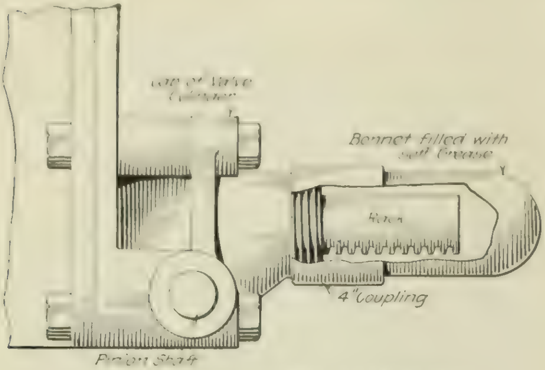


PIPING HOT-WATER RADIATOR

Brooklyn, N. Y. W. T. Meinzer.

Lubricating Rack-and-Pinion Gears

The accompanying sketch shows the device adopted by a local engineer for lubricating the rack-and pinion gears that shift the operating valves of a pair of horizontal-cylinder hydraulic elevators in his charge. The racks are made of steel and the pinions of brass. In the original design of the machine no provision was made for getting oil to the meshing contacts of the gears in the horizontal position. On this account the wear of the pinion was excessive, necessitating frequent renewals. To correct this the engineer threaded the cap of the valve casing to receive a 4-in. pipe coupling having a cup-shaped grease receptacle attached as shown.



RACK-AND-PINION GEAR LUBRICATOR

The engineer figures that the lubrication thus secured has increased the durability of the brass pinions tenfold. A. J. DIXON.

St. Louis, Mo.

Voltage on Generators Varies When Being Paralleled

In the plant where I am employed are three compound-wound 220-volt generators. The capacities of the three machines are 75, 200 and 300 kw. respectively, and they are arranged to be connected in parallel through three-pole switches. All three generators are steam-engine driven.

The machines give no trouble when operating in parallel, but when cutting them in or out of service the voltage varies to such an extent as to affect the speed of the motors out in the plant. Although this change in speed is for only a very short period, it is sufficient to affect the product being manufactured by the machinery driven by the motors. I would appreciate some advice from the readers of *Power* as to the best remedy for this trouble. CHARLES A. ARMSTRONG.

Philadelphia, Penn.

A Home-Made Tachometer

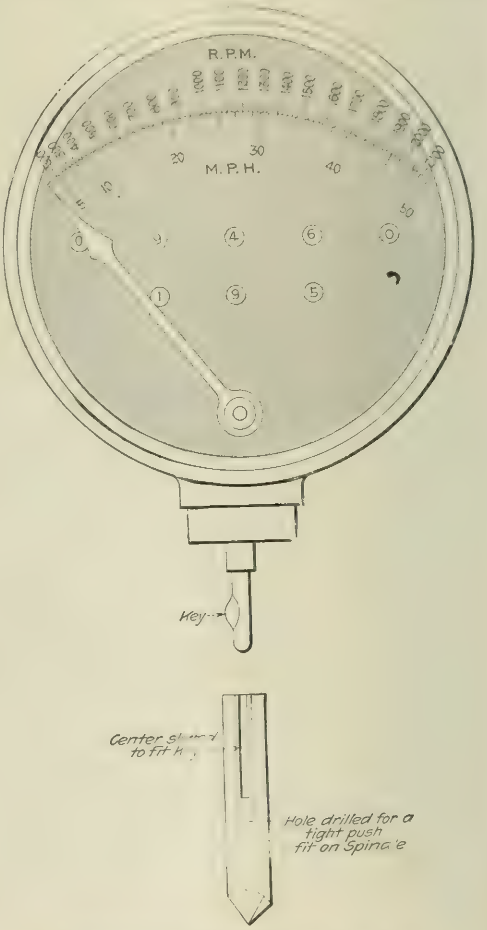
Needing a hand tachometer, I procured from the local garage an old automobile speed indicator that was in good condition and made a temporary handle to go on the spindle, so that I could turn it and count the revolutions. I then counted the number of revolutions the spindle would have to make per mile of the recording dial, which in this instance was 2560.

The next thing was to find how many revolutions per minute were equal to one mile per hour: $2560 \div 60 = 42\frac{2}{3}$ r.p.m. = 1 mile per hour. I then pasted a piece of tracing cloth over the old dial and worked out the points on the scale corresponding to 200 r.p.m., 300 r.p.m., etc., up to 2100 (the limit in this case was 50 miles per hour or $2133\frac{1}{3}$ r.p.m.) thus: 200 r.p.m. $= \frac{200}{42\frac{2}{3}} = 4.72$ miles per hour; 300 r.p.m. $= \frac{300}{42\frac{2}{3}} = 7.08$ miles per hour, etc.

I then marked these points on the tracing cloth corresponding to the miles per hour and marked the r.p.m. opposite, and after the whole scale was worked out, subdivided these divisions into smaller divisions equal to 25 r.p.m., thus completing the scale.

A piece of round steel was drilled the exact size of the spindle, and a slot made in it to fit the key on the spindle. Having got this fitted, it did not take long to file up a diamond-point center and harden it. This completed a handy speed indicator, which is accurate enough for most purposes. D. JAMES.

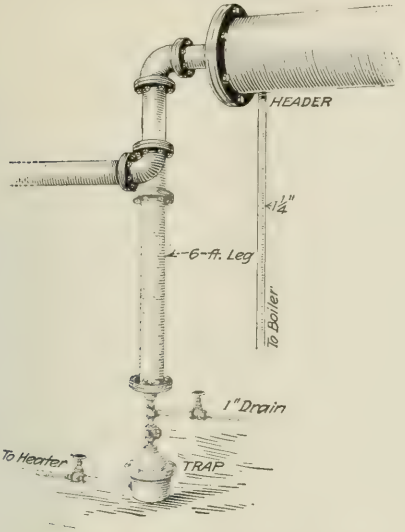
New York City.



GRADUATIONS ON TACHOMETER DIAL

Changes In Header Piping

The change in piping illustrated on page 219 of the Feb. 11 issue was unnecessary. I have the same kind of a header, with a 6-in. outlet connected like the one shown, and it was only necessary to put in a 1¼-in. drip pipe near the end of the header and connect it to the boiler. It gives the results desired, there is no trap to cause trouble and the extra radiating surface is not excessive.



DRIP ANSWERS AS WELL AS TRAP

W. H. WAKEMAN.

New Haven, Conn.

[The elbow in the pipe line shows the original connection. The lighter shaded tee and drop leg represent the changes made by the engineer.—Editor.]

Trouble with Belt Tighteners

In the Dec. 10 issue, page 856, J. S. Eckert described the trouble he was having with idlers used with a couple of belt drives, and in the Jan. 21 issue, page 101, he reports that the trouble was overcome by turning off the crown of the idler pulleys. The fact that the problem was solved by turning the crown off the idler pulley would indicate that the crown was the cause of the difficulty, but was it? This is but one of those half-truths which, someone has declared, are more dangerous than untruths.

When a belt gives trouble by running off the pulley, it should be ascertained whether the shafts are parallel and if the belt is true. A slipping belt or one out of true will run off a crowned pulley quicker than it will run off a straight-faced pulley. This is because of the tendency of the less-stretched edge to run up on the crown.

The belt manufacturers had informed Mr. Eckert that his trouble was partly due to the excessive width for such a thin belt (belt 48 in. wide, ⅜ in. thick). As suggested, the trouble seems to have been caused by uneven stretching of the belt, which has the same effect as if the pulleys were out of line. Turning off the crown of the pulley did not remove the cause of the trouble. Crown on a pulley will not cause a properly installed belt to leave the pulley, but has the opposite effect—witness the many drives operating successfully with crowned pulleys. C. O. SANDSTROM.

Kansas City, Mo.

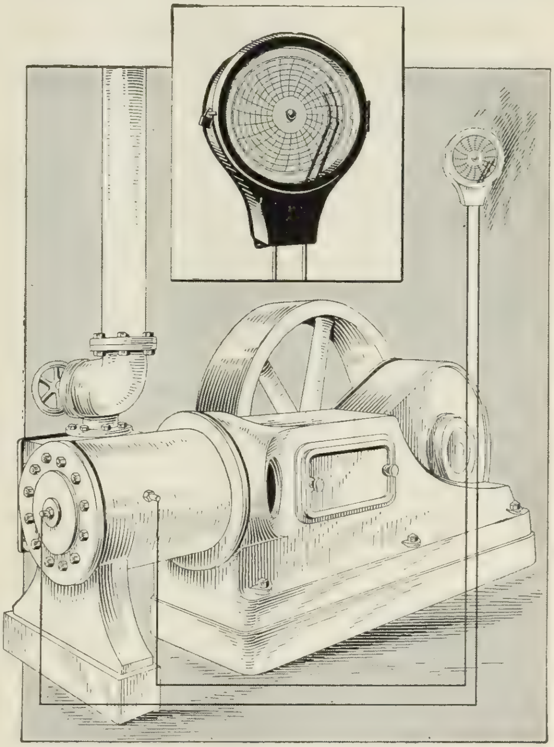
Better Cylinder-Oil Testing Methods Are Needed

Professor Trink's letter on page 644 of the Oct. 29 issue of *Power* calling for a discussion of better methods of lubrication tests of steam cylinder oils was read with interest, and I have been disappointed that it has called forth no more discussion than has appeared so far.

It seems to me that the proper place to test a cylinder-lubricating oil would be in the cylinder of the engine in which it is to be used. The problem then would be one of devising some means of ascertaining the internal condition of the cylinder at all moments during the test.

Friction, as we all know, produces heat and a lack of lubrication produces friction. Then why not devise a method of determining what portion of the heat of the cylinder is due to steam temperature and what portion is due to friction, introducing oil until the friction is reduced to a minimum.

I would suggest attaching a recording thermometer to the center of the cylinder wall and one to the center of the cylinder head, having both temperature lines drawn on the same chart at the same time. The bulb attached to the head would indicate (nearly) the temperature due to steam, and the bulb attached to the center of the cylinder wall (where the piston speed is the



PROPOSED METHOD OF TESTING CYLINDER LUBRICATION greatest) would give the temperature due to steam temperature plus that due to friction.

Assuming that under normal operating conditions both instruments recorded the same temperature, then a lack of proper lubrication would show itself in a rise on the line drawn by the thermometer attached to the cylinder wall; or assuming that the center of the cylinder wall indicated normally a slightly higher temperature and the steam pressure changed periodically, then it would be possible to note a lack of lubrication by a wider divergence of the two lines.

New York City. WILBERT WALTON CRANFORD.

Hand-Damper Regulation

The letter on page 182, of the Feb. 4 issue of *Power*, on hand-regulation of dampers, by T. Henwood, cannot be too highly commended. No one knows better than the operating engineers who, under the direction of the United States Fuel Administration, acted as volunteer inspectors of the many abominations in the shape of hand-damper control apparatus in use throughout the country. In some plants the damper is never used except when a boiler is taken off the line and it is found that a stick, a brick or perhaps a poker regulates the damper position.

If the owners of plants could only realize what an enormous saving in fuel can be effected by the judicious use of the draft control, they would soon see the advisability of making such control as easy of operation as is the opening and closing of the feed valve. Then if a gage is installed that will show the strength of the draft or differential through the fire, the first step will have been accomplished. A few dollars will purchase a steam-flow meter for boiler use, and then the most ignorant fireman will soon realize that for a given steam output a certain draft, as shown by the gage, is required. This draft requires a certain damper position and it needs no expert to determine just what to do to obtain these conditions.

Perhaps the owner will answer such an argument by saying that his operating force would soon tire of the constant observation of such devices. Has he ever given thought as to starting a bonus system for his power-house employees? Some think that this would require an endless amount of bookkeeping and thus claim that such a system could not be adopted in their plants on account of the difficulty of charging costs properly. Almost every steam plant has a unit of output, whether it be barrels of flour, sacks of cement, square feet of heating surface, kilowatt-hours, gallons of water pumped, or any manufactured commodity.

Let the owner look over his coal bills and find what they were at a time when the plant was new, or when he had what he considered the best of engineers. Then let him take the coal bill during that period as a criterion, go to his engineer and tell him that any saving of coal will be split "fifty-fifty" between the office and the operating force. Also explain that a saving of half a ton of coal a day at $4 a ton will mean a division of $1 between the day engineer and fireman and the night engineer and fireman.

Only 25 cents a day to be sure, but that means $7.50 per month, and after the first month that the firemen receive the bonus just watch their "smoke." There-after watch them get torches or candles and go after those leaks. See how they will cut the damper to the minimum amount during cleaning periods so as to reduce the inrush of excess air into the furnace as much as possible; also expect an urgent call for boiler-wall cement. Examine the ash pile and see how the combustible matter in it has decreased. Also see how soon it will be noised around that such and such a plant is a good place in which to work, and not only will there be an increase in the savings from month to month, but the very personnel of the crew will be better, with obvious results.

Of course the owner must do his part. He can do a lot of educational work by putting up a few signs such as: "Excess Air Means Decreased Bonus"; "Damper Wide Open With Furnace Doors Open Means a Loss of Fuel"; "Watch for Cracks in the Settings"; "Don't Let Safety Valves Blow"; "Coal in Ashes Means a Loss."

A few such signs will go a great way toward educating the men, and when they know the effect on the amount of bonus, the result is magical.

Louisville, Ky. JOHN F. HURST.

Dividing Box with Condensing Head

The dividing box illustrated on page 132 of the Jan. 28 issue of *Power* has, I think, one serious disadvantage. The V-shaped columns of water discharging over the weirs of the intake lines to the heaters trap a great deal of air.

Condensate absorbs a large proportion of this air, and if the temperature of this water is not raised to 205 deg. or over, the oxygen is not driven off. The result is increased work for the air pump of the main units.

If the discharge opening to the heater is sealed by using a gooseneck, vented on top to prevent a siphon effect, this condition can be overcome.

Brooklyn, N. Y. C. L. VANCE.

Generator Heats Excessively

There are many possible causes for Mr. Burkard's generator heating, referred to in the article, "Generator Heats Excessively," Jan. 21 issue of *Power*. If the brushes do not heat, it is not likely that the heating is caused by any inherent characteristic in them. Low insulation resistance of the generator windings, or the machine being installed in a damp place might cause heating. The bearing on the opposite end of the shaft from the commutator may be heating and the heat may travel along the shaft into the armature.

New York, N. Y. PATRICK MOLLOY.

Advantage should be taken so far as possible of low-load periods to reduce the peak-load difficulties of the plant. For instance, boilers should be blown at noon hour or other times of light load, and this is the time to fill water tanks, charge storage batteries, blow tubes, run ash and coal conveyors, etc.

Into North Dakota there are now being imported annually two million tons of bituminous coal and one million tons of anthracite, every pound of which should and some day will be replaced with fuel from the Dakota lignite field.

INQUIRIES OF GENERAL INTEREST

Size for Cold-Rolled Steel Head Shaft—What size of cold-rolled steel shaft should be used at 200 r.p.m. for receiving and transmitting 100 hp.? E. T.

The formula for cold-rolled head shafts carrying main receiving or driving pulleys and well supported by bearings is $hp. = d^3 \times$ r.p.m. ÷ 100, in which d = diameter of shaft in inches. For 200 r.p.m. and 100 hp., the formula would become $100 = d^3 \times 200 \div 100$, from which $d = \sqrt[3]{50} = 3.684$, or $3\frac{11}{16}$ in.

Weight of Water Discharged Over V-Notched Weir—What is the formula for the number of pounds of water at 60 deg. F. flowing over a 90-deg. V-notched weir? T. E. S.

The formula for flow over a 90-deg. V-notch weir is cu.ft. per min. = $0.306 \sqrt{h^5}$, in which h = the head of water measured in inches above the apex of a symmetrically placed V-notch made in "thin plate" or beveled for clearance on the discharge side of the wear. One cubic foot of water at 60 deg. F. weighs 62.3677 lb., and for that temperature the weight of water discharged would be $62.3677 \times 0.306 \times \sqrt{h^5} = 19.08 \sqrt{h^5}$. lb. per min.

Preference for Standard-Weight Pipe—For general power-plant work and for pressures upward of 300 lb. per sq.in., why is 6- to 8-in. standard pipe preferred to the extra-heavy? W. E. A.

Standard-weight pipe is preferred to extra-heavy on account of greater flexibility. Extra-heavy pipe is considered to be more appropriate where pipes occupy inaccessible places or are especially exposed to corrosion. For 300 lb. pressure the factor of safety of standard pipe would be about 2½, while extra-heavy would give a factor of safety of about 4½. The selection with respect to safety must be left to the discretion of the designer.

Coal Required for Heating Air—A fan delivers 36,000 cu.ft. of air per minute through steam-heating coils. What amount of coal of 10,000 B.t.u. per lb. will be required to raise the temperature of the air from 10 deg. F. below zero to 70 deg. above zero? C. C. P.

The specific heat of dry air at constant pressure is about 0.2376 and at —10 deg. F. the weight per cubic foot would be about 0.0882 lb. As the elevation of temperature would be 80 deg., the heat required would be 36,000 × 60 × 0.0882 × 0.2376 × 80 = 3,621,252 B.t.u. per hour. Allowing a boiler efficiency of 60 per cent. to be obtained with coal of 10,000 B.t.u. per lb., would require, 3,621,252 ÷ (10,000 × 0.6) = 604 lb. of coal per hour.

Fuse Blown on Three-Phase Motor—What would be the effects of a fuse blowing in either of the primaries or secondaries of three transformers connected in star, to a three-phase motor? B. R.

The opening of a fuse on either side of the transformer bank would leave the motor operating single-phase. If the motor is lightly loaded it will continue to run until shut down, but cannot be started again until the fuse is replaced. While the motor continues to operate single phase it will take about 100 per cent. more current in the active phase than when operating three-phase. The single-phase pull-out torque will be from 30 to 40 per cent. of what it was for three-phase operation.

Results of Evaporative Test—In an evaporative test of 10 hours' duration, three water-tube boilers having respective rated capacities of 265, 265 and 400, or a total of 930 boiler horsepower, evaporated 313,000 lb. of water fed at 166.4 deg. F. into steam at an average gage pressure of 150 lb. per sq.in. with 6 per cent. moisture. There was 57,535 lb. of coal burned with 8678 lb. of ash and refuse. What was the equivalent evaporation from and at 212 deg. F. per pound of coal and per pound of combustible and what percentage of the rated capacity wa developed? P. T. J.

One pound of dry saturated steam at the pressure o 150 lb. gage, or 150 + 15 = 165 lb. absolute, contains 119 B.t.u. above 32 deg. F., and the heat contained per poun of the liquid is 338.2 B.t.u. above 32 deg. F. Hence, eac pound of the feed water at the temperature of 166.4 deg F., for conversion into steam at 150 lb. gage pressure wit 6 per cent. moisture, must have received 94 per cent. o 1195 + 6 per cent. of 338.2 — (166.4 — 32) = 1009.19 B.t.u. Evaporation of a pound of water from and at 21 deg. F., requires 970.4 B.t.u., and for the conditions state the factor of evaporation is 1009.192 ÷ 970.4 = 1.039 The evaporation under actual conditions was 313,000 ÷ 57,535 = 5.44 lb. of water per pound of coal and 313,00 ÷ (57,535 — 8678) = 6.406 lb. of water per pound o combustible, so that the equivalent evaporation from an at 212 deg. F. was 5.44 × 1.0399 = 5.657 lb. of wate per pound of coal and 6.406 × 1.0399 = 6.662 lb. of wate per pound of combustible.

A boiler horsepower is equivalent to evaporation of 34. lb. of water from and at 212 deg. F. per hour, and therefore the evaporation developed was $\frac{313,000 \times 1.0399}{10 \times 34.5}$ = 943.44 boiler hp., which is (943.44 — 930) ÷ 930 = 0.0144 or about 1½ per cent. greater than the rated capacity.

Lower Allowable Pressure Requires Larger Safet Valve—Two boilers are of the same dimensions throughout and each is provided with the same size of grate kind of fuel and draft, and the temperature of feed wate in each case is to be 200 deg. F. One of the boilers i allowed to carry a working pressure of 50 lb. gage an the other 150 lb. gage. Which should be provided wit the larger safety valve? E. L.

The boiler that is allowed the lower pressure should b provided with the larger safety valve. From the identit of the boilers and settings, it is to be presumed that eac will transmit the same amount of heat in generation o steam. A pound of steam at 50 lb. gage, or 65 lb. absolute, contains 1178.5 B.t.u., and for generation from fee water at 200 deg. F., each pound would receive 1178.5 — (200 — 32) = 1010.5 B.t.u. A pound of steam at 150 lb gage, or 165 lb. absolute, contains 1195 B.t.u., and fo conversion of the feed water into steam at this pressur each pound must receive from the boiler 1195 — (200 — 32) = 1027 B.t.u. Therefore, for the same heat generate by the furnace and transmitted by the boiler, there woul be $\frac{1010,5}{1027}$, or about 98 per cent. as many pounds of stea generated at the higher pressure. Napier's approximat formula for the discharge of steam from a safety valv is: Flow in pounds per second = absolute pressure × area in square inches ÷ 70; that is, the escape area required is directly as the weight and inversely as the absolute pressure, so that the safety valve for dischargin steam at 165 lb. absolute would need to have only 98 per cent. of $\frac{65}{165}$, or about 40 per cent. as much area o opening as for discharging as much steam as would b generated at 65 lb. absolute for the same amount of hea transmitted by the boiler.

[Correspondents sending us inquiries should sign thei communications with full names and post office addresses This is necessary to guarantee the good faith of th communications and for the inquiries to receive attention.—Editor.]

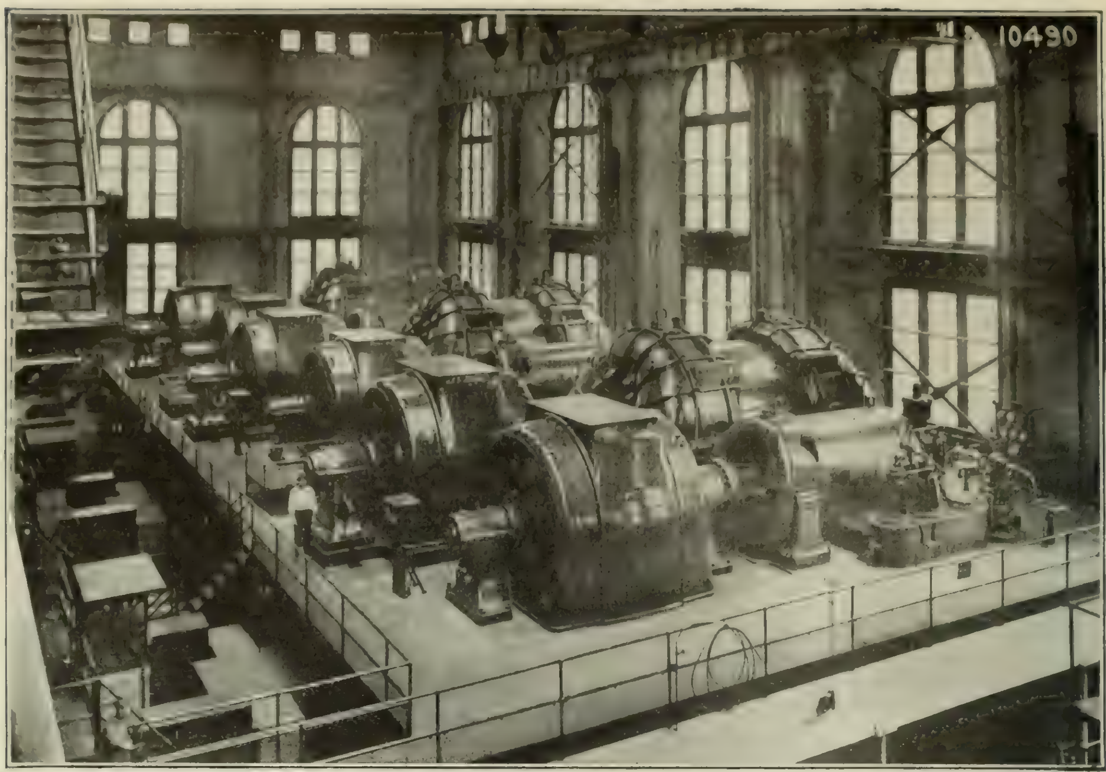


FIG. 1. THE 30-000-KW. COMPOUND TURBINES, INTERBOROUGH RAPID TRANSIT CO., NEW YORK

Notes on Large Steam-Turbine Design*

By J. F. JOHNSON
Engineer, Turbine Department, Westinghouse Electric and Manufacturing Company

The author discusses those factors that influence the determination of the size of steam turbines for modern power stations. He follows this with a valuable description of the operation of large reaction turbines which have been recently installed.

THE remarkable growth of the electric-power industry during recent years has been paralleled by an equally remarkable growth of steam-turbine-driven generating units. So rapid has this development been that frequently before the first machine of a new design was completed, another of materially greater capacity and higher efficiency was being designed.

While machines of 15,000-kw. capacity were put into operation as early as about 1908, their use did not become general until 1913; whereas today nearly every one of what may be called large generating stations has at least one unit of 30,000-kw. capacity or larger in service or on order.

Has this growth been natural, logical and healthy, or has it suffered temporarily from overstimulation which is destined to result in a relapse, or reversion to smaller sizes? If such reversion occurs, will it be the result of faulty engineering, born of overconfidence on the part of the builders of the apparatus or on the part of the users? That is, will be because units of necessary reliability and economy are not commercially obtainable, or because units of 30,000 kw. and larger are too large for the present and immediate future requirements of large power-generating stations?

In the following table is given roughly approximate figures showing for several districts, each included within a circle of about ten miles radius, the total capacity in kilowatts of generating units which will have to be installed by 1920, based upon an estimated increase of peak load of 8 per cent. each year and a surplus of generating capacity installed above peak load of 20 per cent.

District	Sum of Maximum Sustained Peak Load, All Companies, 1917	Total Capacities To Be Installed by 1920
New York	800,000	1,190,000
Chicago	400,000	596,000
Philadelphia	250,000	373,000
Buffalo and Niagara Falls	300,000	447,000
Detroit	155,000	231,000
Boston	155,000	231,000

In the selection of sizes of generating stations the choice of sizes of generating units is important because the number and sizes of units in a station of given capacity will materially affect the total cost of power generated. If the sizes of units be too small and the number too large, the cost per kilowatt of the station completed will be greater, the maintenance and operating expenses higher, the efficiency poorer and reliability at least no greater than if the proper sizes are used. On the other hand, if the units be too large, the cost per kilowatt installed may be too large because of the greater reserve or stand-by capacity required, and the efficiency may even be poorer by reason of the units operating at loads too far below their points of best efficiency.

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*Abstract of a paper read before the Philadelphia Section, American Society of Mechanical Engineers.

Take for example, a district with a maximum peak requirement of 600,000 kw., which to insure proper reliability it is decided to generate in three stations of approximately equal sizes. We will assume that these stations will normally always operate in parallel with each other and that there will be one spare unit for each five in service during the peak. If 20,000-kw. units are used, there will be 30 operating and 6 spares, making a total of 36 units, 12 in each station. If 30,000-kw. units are used, there will be a total of 20 operating and 4 spares, making a total of 24 units, 8 in each station. If 40,000-kw. units are used, there will be a total of 15 operating and 3 spares, making a total of 18 units, 6 in each station. If 60,000-kw. units are used, there will be a total of 10 operating and 2 spares, making a total of 12, 4 in each station.

If, to remove from this consideration of ideal size of units conditions imposed by the design of the apparatus, it is assumed that irrespective of the size the reliability, efficiency and purchase price per kilowatt will be the same, it should be obvious without resorting to calculations that the 20,000-kw. size is too small and that best results are to be expected with either the 40,000- or 60,000-kw. sizes, because the installation costs, including buildings, foundations, piping and switching equipment, and operating costs, including maintenance, supplies and attendance, should be less per kilowatt; the efficiency higher because of the higher efficiency of the larger units, larger auxiliaries and smaller friction and radiation losses in the larger steam and water piping; and reliability greater because of the smaller number of operations of starting and stopping and cutting in and out of service of units necessary.

In so far as conditions affected by the design of units are concerned, it is quite generally appreciated that in sizes up to at least 30,000-kw. capacity, higher efficiency at the same cost per kilowatt is obtainable purely by reason of the larger size and still higher efficiency for a slight increase in cost per kilowatt, and it has been quite conclusively demonstrated that as high a degree of reliability is obtainable in these larger units as in the smaller ones. Fig. 10 shows the approximate relative steam consumption rate of units in sizes varying from 5000-kw. to 40,000-kw., all designed for the same cost per kilowatt.

While districts in which the peak requirements of any one operating company are as great as from 400,000 to 600,000-kw. are at the present time not numerous, there are many that will probably reach that stage before in-

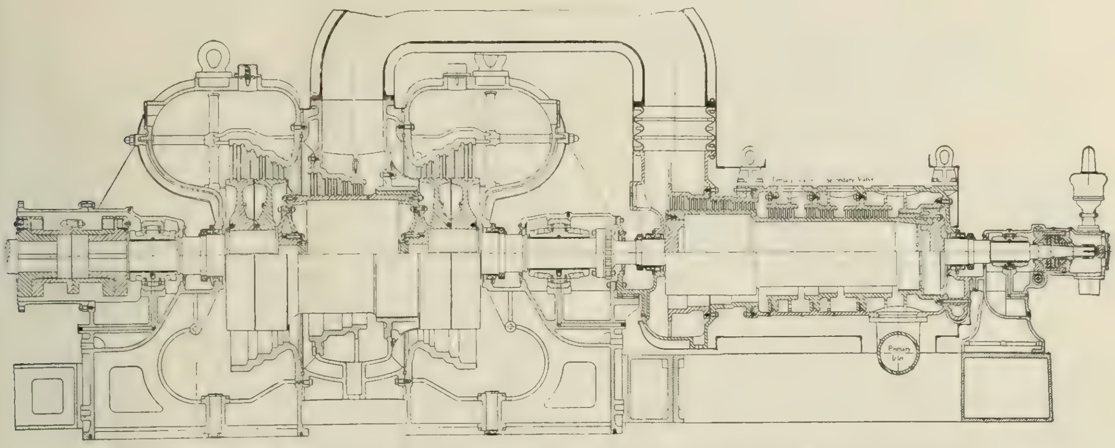


FIG. 2. CROSS-SECTION OF 30,000-KW. REACTION TURBINE, COMMONWEALTH EDISON CO.

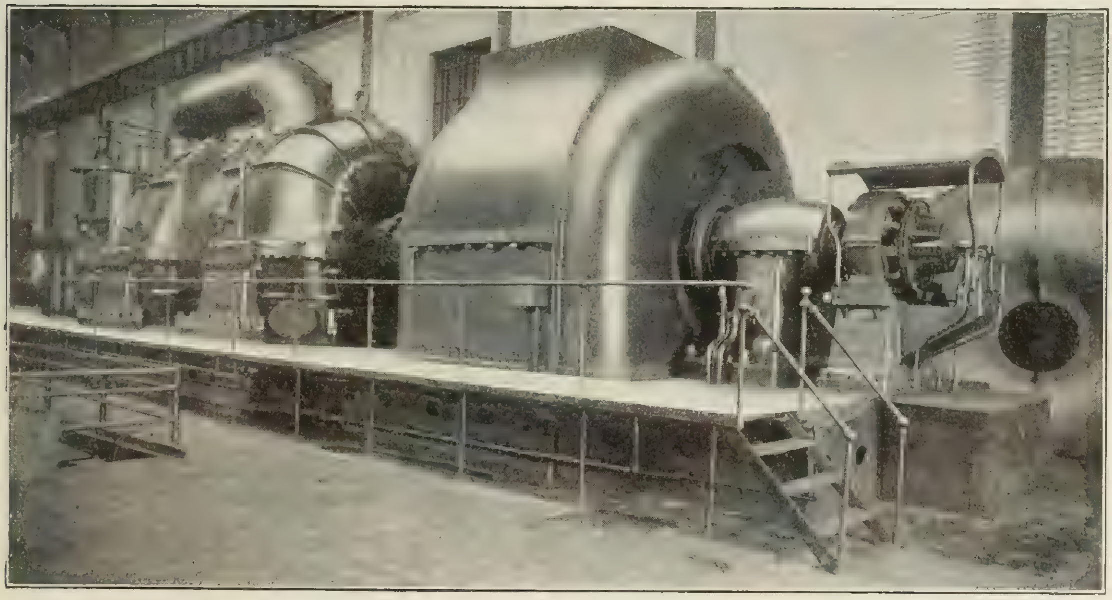


FIG. 3. GENERATOR END OF THE TANDEM COMPOUND MACHINE AT CHICAGO

stallations being made at this time will be expected to become obsolete. In these, units of the larger sizes should be introduced to replace smaller ones as they become obsolete and to take care of increasing requirements at such a rate as will effect the most economical production of power over the estimated period of usefulness of the machines installed. It will be in order here to make mention of the fact that numerous generating stations of about 200,000 kw. installed capacity, projected and designed by the ablest engineering talent in the country, are under construction and in operation, and units of 30,000 kw. and larger are being employed in them; also that stations of approximately 300,000 kw. installed capacity are being projected and will probably be built in the near future.

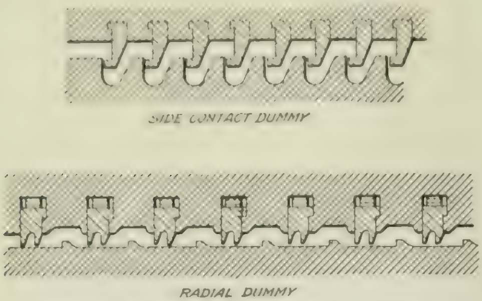


FIG. 4. SECTIONAL VIEWS OF DUMMIES

Appreciating the need of generating units of large capacities in the future growth of the electric-power industry, the engineering staff with which the writer is associated several years ago took up the work of designing such machines, assured themselves of their feasibility, and advocated their use. A number of them have now been in operation several years.

Up to the present a total of 14 units have been sold, varying in capacity from 30,000 to 70,000 kw. maximum. Of these 11 have been shipped, 10 are in service, and 7 have been in service for periods varying from approximately one to five years. The records of performance of these machines should emphatically remove any doubt as to the commercial possibility of units of large capacity, and satisfactorily prove that at least within limits not yet reached, increase in size need not impair reliability and may improve efficiency.

The first three of these units, which are exact duplicates, were sold to the Interborough Rapid Transit Co., of New York. They are of the two-cylinder cross-compound pure-reaction type, and designed for maximum reliability and efficiency. These units are shown in Fig. 1.

They are of 30,000 kw. maximum rating with point of highest efficiency at 25,000 kw., operating with 205 lb. steam pressure, 120 deg. F. superheat, 29 in. vacuum referred to 30 in., the high-pressure operating at 1500 r.p.m., and the low-pressure at 750 r.p.m. [A description of these units appears in *Power* for Apr. 20, 1915.]

The first one was put in service Dec. 30, 1914, the second in February and the third in August, 1915. Elaborate and exact steam-consumption tests were conducted on the first of these units by the purchaser. (See paper by H. G. Stott and W. S. Finlay, presented at May, 1916, meeting of New York Section of the A. S. M. E., also *Power* for May 23, 1916, p. 746.)

These units, since their installation, have been operating on an average of from sixteen to twenty hours per day, on fluctuating railway loads varying from 10,000 to 30,000 kw. With the first and third no troubles of any sort have been experienced, and they have been ready at all times for any service within their designed capacity except when out of service for regular periodic inspection or ordinary maintenance. On the second the labyrinth packing on the balance pistons of the high-pressure element has failed three times, requiring renewal of some parts. The cause of these failures was at first supposed to have been improper adjustment, but investigations following the third failure indicated excessive lost motion in the thrust bearing and heavy distortional stresses, caused by rigid bracing of the steam pipe near the turbine as the probable causes.

The fourth unit, placed in operation in the Northwest Station of the Commonwealth Edison Co., Chicago, in September, 1917, consists of a tandem-compound pure-reaction turbine, direct-connected to a single generator. It has a rating of 30,000 kw. with an additional overload capacity of 5000 kw. operating with 220 lb. steam pressure, 200 deg. F. superheat, and 29 in. vacuum, 1200 r.p.m. These are shown in Figs. 2 and 3.

A few hours after being put into service, subsequent to completion of erection, the labyrinth packing on the low-pressure element failed, due, we think, to buckling of the turbine cylinder, caused by rigid piping connections between the two surface condensers, which are bolted rigidly to the two exhaust openings on the turbine, preventing the condensers from translating with the turbine as its temperature increased. Temporary repairs were made locally and the unit put in service in about four weeks. It has been operating almost continuously since without trouble (except cracking of a copper expansion joint), carrying loads as high as 40,000 kw. In one instance it was kept on the line for 71 days, and then taken off only to clean the condenser. Material for making permanent repairs to the labyrinth packing was shipped to the station within a few months after the accident, but purchaser has not yet given permission to take the unit out of service long enough to install it. This packing in section is shown in Figs. 4 and 5.

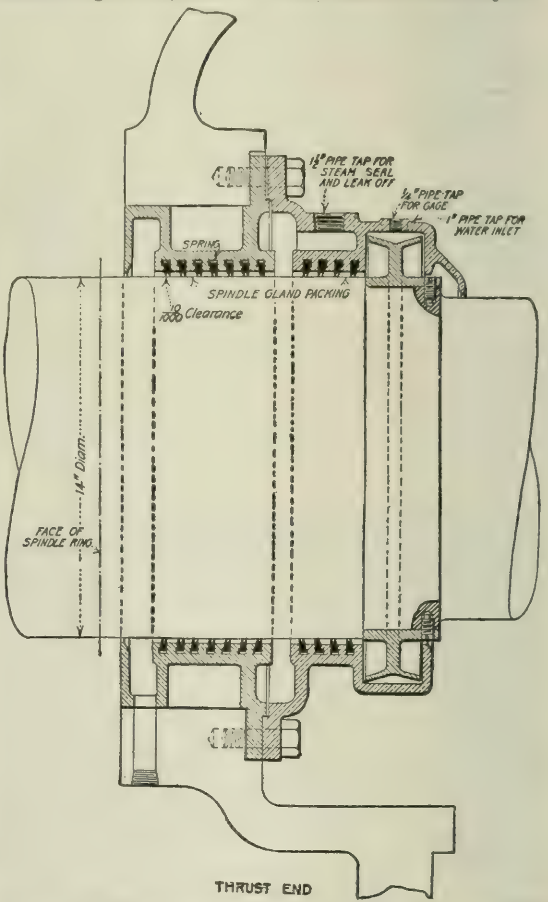


FIG. 5. GENERAL ASSEMBLY OF LABYRINTH PACKING

The fifth unit, a 30,000-kw. pure-reaction single-cylinder machine, operating on 200 lb. steam pressure, 100 deg. superheat, 29 in. vacuum, was placed in operation in the

Gold Street Station of the Edison Electric Illuminating Co., of Brooklyn, in October, 1917. Owing to congestion in the shops and urgency of shipment, this turbine was not operated prior to shipment. The overspeed test was made after installation. No correction of balance was necessary, and with the exception of a few leaks in the oiling system and the breaking of a defective gear on the oil pump drive, no trouble has been experienced. It has been available for service at all times and has been operating approximately continuously except over Sundays and when necessary to clean the condensers, at average loads of approximately 23,000 kw., and peak loads as high as 32,000 kw.

The sixth unit, placed in service in December, 1917, in the Kent Avenue Station of Brooklyn Rapid Transit Co., is a duplicate of the fifth machine. Just after installation some rebalancing of both turbine and generator rotors was necessary. On Oct. 18, after having been in service about ten months, the Kingsbury thrust bearing overheated and wiped some, but did not damage any other part of the machine. When opened for inspection, it was found that the labyrinth packing strips, which were made of an aluminum alloy, were considerably corroded by the action of strong alkalies used at this plant for treating feed water; and two rows of blading in the high-pressure portion of the machine were found to have been damaged at some previous time, caused probably by foreign matter or a defective blade. This machine was in regular service up to Oct. 18, carrying maximum loads as high as 31,000 kw. and an average of 25,000 kw. The thrust bearing is shown in section in Fig. 6.

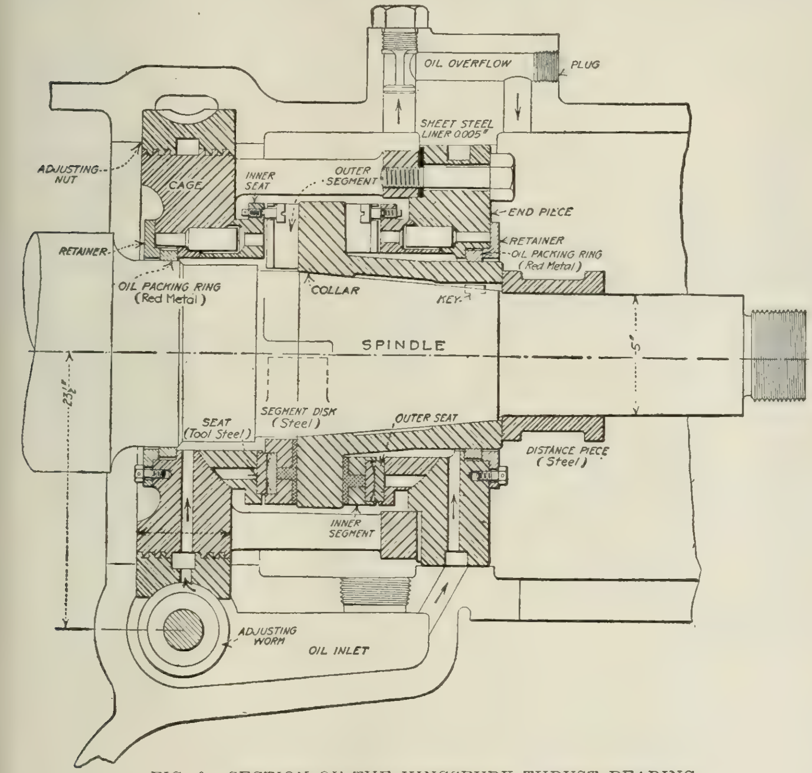


FIG. 6. SECTION OF THE KINGSBURY THRUST BEARING

The seventh unit is a 40,000-kw. 60-cycle cross-compound machine, installed in the Brunots Island Station of the Duquesne Light Co., and was placed in service in December, 1917. The high-pressure element of this machine operates at 1800 r.p.m. and the low-pressure at 1200 r.p.m. This unit has been in regular service carrying loads normally of from 30,000 to 40,000 kw. with peaks as high as 50,000 kw. On Feb. 18, while operating the machine to correct the balance of one of the generators, the main bearing at the coupling end of the high-pressure turbine burned out, apparently due to interruption of oil service to that bearing. This let the spindle down sufficiently to cause rather heavy blade rubs throughout the machine. The bearing was rebabbitted and the machine put back in service without any other work being done except rechecking the clearances and placing a balance weight on the spindle to correct for the weight rubbed off the blades. In July the generator was damaged by electrical trouble, and while this repair was being made, both elements of the turbine were dismantled. The high-pressure rotor was returned to the shops, the damaged blading replaced and rebalanced. New blading was also installed in the stator to restore original clearances and original efficiencies. Inspection of the low-pressure element revealed several broken blades which were defective and had slightly damaged the rest of the blading in those rows, requiring replacement of approximately 1½ rows of blading on each end of the machine. The eighth unit, practically a duplicate of the seventh, rated at 45,000 kw. maximum, was placed in service for the Narragansett Electric Light Co. in Providence in January, 1918. [For description with excellent drawings of this machine see *Power* for Aug. 27, 1918, p. 292.] In placing this machine in service the labyrinth packing on the high-pressure element was damaged, due to improper adjustment, which necessitated temporary repairs, keeping the machine out of service until about Mar. 1. Since then no trouble has been experienced except some distortion of the couplings caused by a series of violent short-circuits and some defective workmanship on the fitting of the coupling keys. Permanent repairs to the labyrinth packing have been made, and new coupling parts are to be installed in the near future. In the meantime the old parts are operating satisfactorily without any evidence of distress. This machine operates on loads as low as 5000 kw., and has carried a peak load of 50,000 kw. for periods of from four to five minutes. Longitudinal sections of the high- and the low-pressure elements are shown in Figs. 7 and 8.

The ninth unit is a 70,000-kw. three-cylinder cross-compound 25-cycle machine, installed for the Interborough Rapid Transit Co. in New York. The one low-pressure element was placed in service Apr. 18, 1918, operating on high-pressure steam. The high-pressure element was placed in service Aug. 21, operating in connection with the low-pressure already installed, and the second low-pressure element was placed in service Oct. 9. Some intermittent vibration trouble appeared on the first low-pressure machine, the cause for which was found to be lack of sufficient clearance on one of the spindle rings, causing distortion during expansion. After this was corrected no further trouble was experienced except the breaking of a few defective blades on the intermediate stage of the second low-pressure. This unit is equipped with an automatic control mechanism for cutting out of service, either automatically or manually, either element without disturbing the other two. These features have been given a thorough try-out, which in so far as a demonstration goes, has verified all expectations as to flexibility of this feature. In regular service it has carried loads as high as 55,000 kw. with swings up to 61,000 kw.

While these records do not all show 100 per cent. perfection, they do show that in not one instance has there been any evidence of inherent or basic defects in design or difficulties in construction or operation. Some troubles have been experienced, but these have all been of minor character, due to avoidable defects in detail design, construction, installation or operation; such as are experienced with new designs of any size or sort. It is significant that with one exception no important part of any one of these units has ever been returned to the works for replacement, alteration or repair. The high-pressure rotor of the Duquesne Light Co. unit was returned to the shops for checking for truth and reblading. While most of them have not been subjected to any accurate steam consumption tests, definite reductions in station coal consumption rates were effected by the installation.

The foregoing naturally leads to a consideration of some of the more important problems of large steam-turbine design and of their solutions. The successful practical design of a large turbine comprises many problems worthy of the highest engineering skill. Many conflicting factors must be most judiciously combined in order to secure the best evenly balanced design and one which will serve the purpose for which it was intended most usefully.

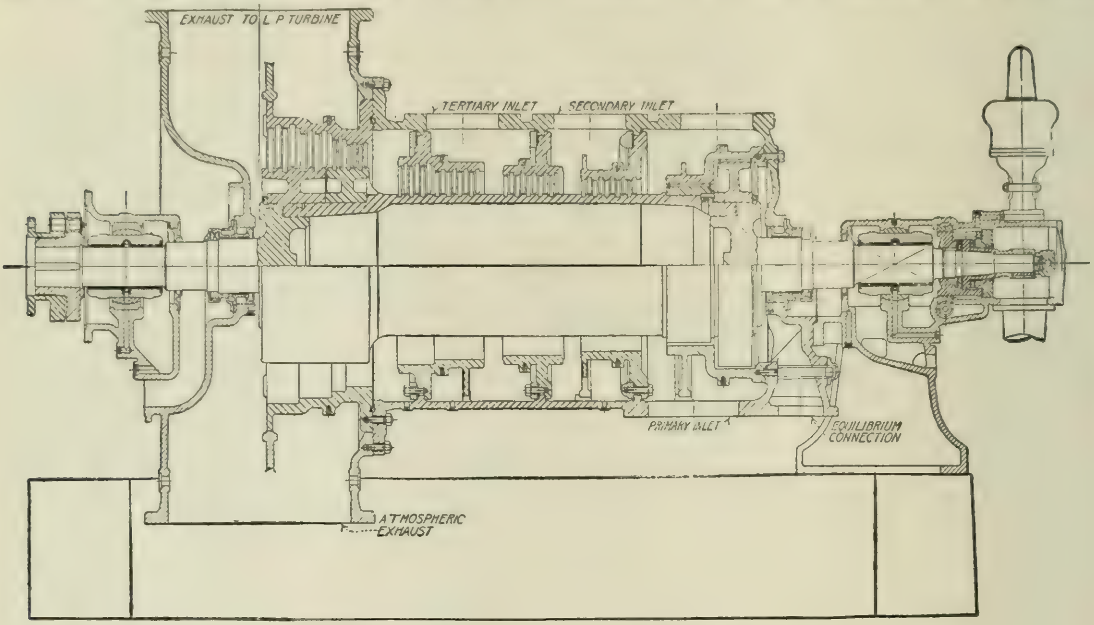


FIG. 7. LONGITUDINAL VIEW OF HIGH-PRESSURE ELEMENT, 45,000-KW. TURBINE

In this as in all other arts, carefully studied and accurately judged experience is the great teacher, and highest success is attained only after years of growth, adhering to the same basic design, the principles of which must be right and therefore susceptible to the highest development.

To begin with, the engineer must have a clear vision of his ideal, his turbine made perfect in every detail. This must be the standard toward which he constantly strives, deviating from it only as compelled to do so in compromising between conflicting factors. In this ideal, *reliability* and *general operative excellence* must stand out as the dominating characteristics, because above all things the machine must be dependable to deliver its rated capacity of kilowatts upon demand; second to this comes *efficiency*, because it must in competition with other units yield a profit for the owner; and third comes *cost*, because the unit must be salable in competition.

The first and perhaps greatest single problem is suggested in the theoretical design; namely, that of providing areas suitable to accommodate the enormous increase in volume of the steam while passing through the turbine. Steam supplied at the throttle at 250 lb. gage pressure and 150 deg. F. superheat enters the first stage at a pressure of about 255 lb. absolute and specific volume of 2.28 cu.ft. per lb. (allowing 10 lb. drop through the throttle and inlet valves). It leaves the last stage at 380 cu.ft. per lb. when 28½ in. vacuum is maintained by the condenser, and 550 cu.ft. per lb. when 29 in. is maintained; that is, the volume when exhausting to 28½ in. vacuum is 166⅔ times, and when exhausting to 29 in. is 241 times as large as it is at the entrance. This means that if the rate of steam flow is such as to require an 18-in. steam inlet pipe, and if its velocity were maintained the same through the exhaust as through the inlet pipe, the exhaust opening when expanding to 28½ in. vacuum would have to be 19 ft. 4 in. in diameter, and when expanding to 29 in. vacuum 23 ft. 4 in. in diameter; or if the mean diameter and exit angle of all the rows of blading be the same and the ratio of blade speed to steam speed be the same in each, thereby keeping the theoretical efficiency of all stages equal, and if these blade and steam speeds be so chosen as to fix the height of the blades in the first stage at one inch, the last row would have to be approximately 13 ft. 10½ in. if designed for 28½ in. vacuum, and 20 ft. 1 in. if it were designed for 29 in. vacuum.

A diagram has been prepared to show this enormous increase in volume and indicated thereon are the relative blade heights based on the assumption of the speeds being kept constant. The impracticability of adhering to such proportions in actual designs is obvious. See Fig. 9.

Here is where the combining of conflicting factors begins. In the first stages the areas and blade heights should be kept large to reduce the losses, and in the low-pressure stages they must be sacrificed on account of practicable limits of mechanical design. In single-cylinder machines where the blading is all on the same spindle, the problem becomes doubly difficult.

The first determination is that of rotative speed, which is usually not difficult to make since the frequency of the generator restricts the permissible speeds to a few and these are rather widely separated. The limiting capacities at the various permissible rotative speeds for which generators can be built must also be considered, although at the present time the practicable limits of turbines and generators is reached at approximately the same capacities except in the case of single-phase generators. With these the limiting capacities are less than with polyphase generators.

The chief factor in the selection of the rotative speed is the design of the last row of blades with reference to height, diameter and exit angle, because this is the most important stage in the whole turbine. In it the mechanical stresses and fatiguing effect of vibration, the B.t.u. drop and physical dimensions are all greatest. Consequently, upon it depend largely the reliability, efficiency and cost of the unit.

Here the temptation of reward in high efficiency without appropriate higher cost by departing from known reliable and conservative practice in the employment of materials and stresses is greatest, and the engineer must needs keep both eyes firmly fixed upon his ideal lest he be led astray by the alluring appeals of a daring commercialism. Here must be considered the alternatives of a higher rotative speed with the low-pressure stage made multiflow as against a slower rotative speed and singleflow construction.

The length of blades must not be excessive with reference to the diameter, not only because of the higher stresses in the blades and rotor, but also because the difference in velocity of the blades at their tips and at their roots, as well as the difference in blade spacing will, if too great, materially impair the efficiency.

On the other hand, if the area through the blades is too much restricted, the steam velocity will become too high and the bearing losses too great. If this restriction is carried to the extreme, the steam in passing through the last row of blades may even reach its critical velocity without expanding entirely down to the condenser pressure, in which event the remainder of the expansion takes place in the form of an explosion upon leaving the blade passages, and from it only a small percentage of the energy is recovered.

To secure the most satisfactory design for the last stages, and in order to permit the stresses or physical dimensions with the ever-present cost from becoming prohibitive, several compromise features are employed. The first of these consists of increasing the rotor diameter and blade heights, if necessary, until the safe limit of stress is reached, keeping the blade height within approximately one-fourth of the rotor diameter as a limit of good practice. The materials of which the rotor and blades are made will of course determine the safe stresses, and on account of the great import of safety and reliability in these parts, only good quality of plain, or 5 per cent. nickel low-carbon steels should be used because these are commercially common materials, uniform in quality and do not require sensitive heat treatments.

For rotors, cast or forged steel having a tensile strength of 70,000 lb., true elastic limit of 28,000 to 30,000 lb. and elongation of 18 per cent. in 2 in. may be stressed to 20,000 lb. per sq.in. and for blades 5 per cent. nickel steel having tensile strength of 85,000 lb. and true elastic limit of 35,000 lb., may be stressed to 25,000 lb., both at 20 per cent. overspeed. The stresses at normal operating speed will therefore be 13,900 and 17,350 lb. respectively, and the factor of safety against rupture approximately five.

Increasing the diameter not only permits increasing the blade height, but also the steam speed without materially affecting the efficiency, by reason of the increase in blade speed. There is, however, a slight falling off in efficiency with the higher speeds even though the ratio of blade to steam speed be kept practically constant because the actual velocity of the steam with reference to the blade being greater, the frictional losses will be greater.

The second compromise consists of increasing the steam-passage area through the blades by changing the blade shape. This change increases the angle between the direction of steam flow from the blade and the direction of the blade, and a slight impairment of efficiency results therefrom. However, this loss is slight compared to the gain from the higher ratio of blade speed to steam speed resulting from the increased area. This practice is standard on practically all condensing machines built for high vacuum.

The third compromise consists of permitting the steam speed to increase without a corresponding increase in blade speed, thereby decreasing the ratio of blade speed to steam speed, and increasing the leaving losses. This compromise

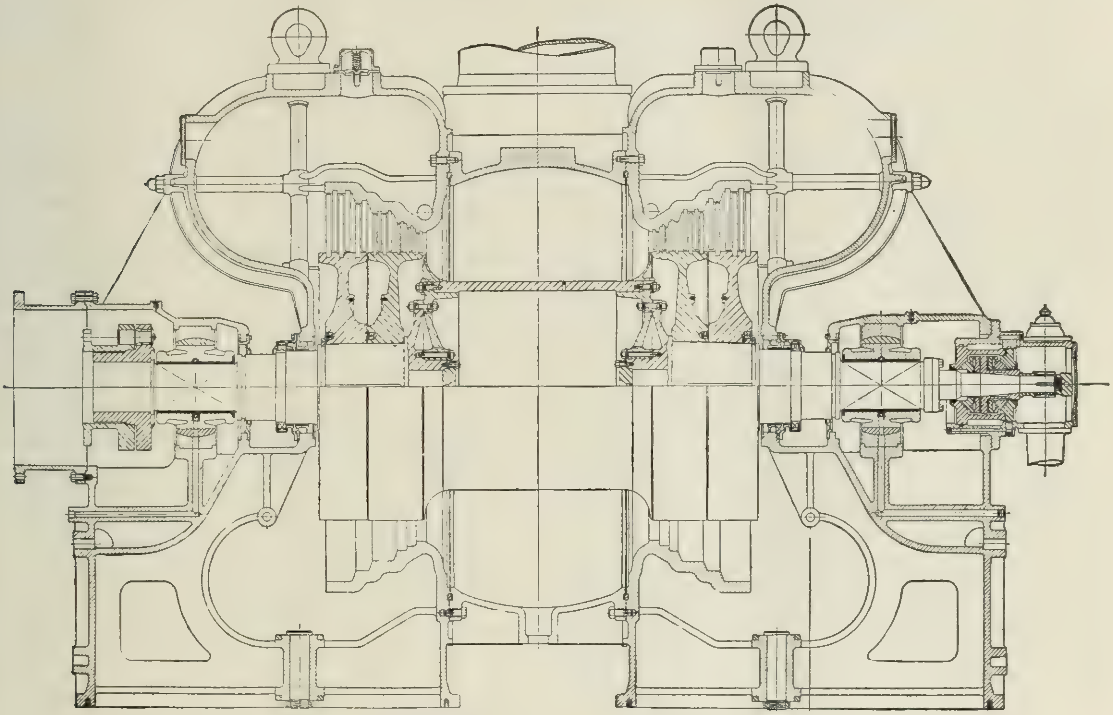


FIG. 8. LOW-PRESSURE ELEMENT OF THE 45,000-KW. TURBINE AT PROVIDENCE

may properly be employed up to the point where the loss of efficiency will justify the increased expense of greater blade areas which may necessitate dropping to a lower rotative speed or employing multiple stages.

Two or more low pressure stages in multiple in connection with a single high-pressure stage are used when the required areas cannot be obtained with a single stage at the rotative speed chosen, and when it is more feasible to employ multiple stages than a lower rotative speed.

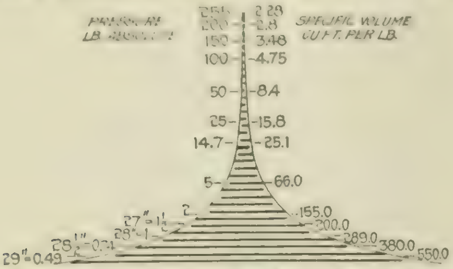


FIG. 9. INCREASE IN VOLUME OF STEAM FOR DIFFERENT VACUUMS AND RELATIVE BLADE LENGTHS REQUIRED

Other considerations favoring multiple stages are (1), reduced physical dimensions of the exhaust chambers, simplifying both the ribbing and bracing necessary to maintain the proper rigidity; and the cylinder-supporting structure, including foundations; and (2), limitations of shipping dimensions established by transportation companies.

The design of the higher stages usually involves only an equitable selection of diameters, blade speeds and steam speeds. Keeping these low results in low stresses and high efficiency, but large number of stages, and high cost; while keeping them high reduces the length, weight and cost, but increases the stresses and impairs the efficiency.

If the steam volumes in the first stages are relatively small for the rotative speed employed, as would be occasioned by the use of high steam pressure or low rating, a double-velocity-stage impulse element may often be employed to advantage, the advantages secured being reduction of length, increased diameter, reduced pressure and temperature inside the main cylinder and adaptability for varying overload capacity, but not increased efficiency nor decreased cost.

Having fixed the rotative speed to secure proper design of the low-pressure stages, and the diameters and steam speeds of the high-pressure stages to give the highest economy, the length of the rotor may become excessive, necessitating its division into two parts to maintain requisite reliability. These parts may be arranged either in tandem form, driving a single generator, or in cross-compound form driving two generators. When arranged cross-compound, it will often be found advantageous to increase the rotative speed of the high-pressure element, thereby gaining reduced physical dimensions, weight and cost, without sacrifice of efficiency or reliability. The multi-cylinder construction is especially desirable in the employment of high steam pressures and superheats in that the high-pressure turbine structure is small and there is no danger of stress complications resulting from wide temperature differences and no transmission of heat through the cylinder walls from the high-pressure to low-pressure stages. It has a further advantage in these days of increasing steam conditions in that a unit may be designed for given steam conditions and later redesigned for materially higher conditions, the redesign being entirely carried out in the high-pressure element.

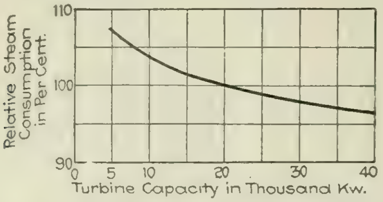
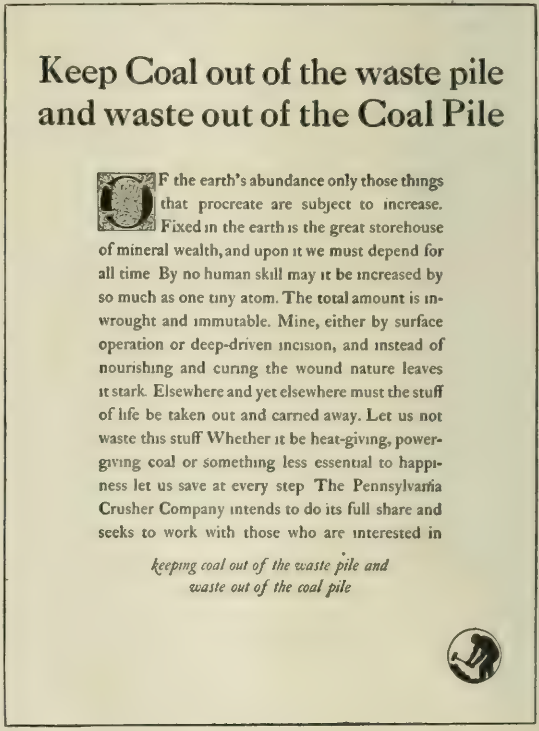


FIG. 10. RELATIVE STEAM CONSUMPTION OF UNITS OF FROM 5000 TO 40,000 KW. CAPACITY, ALL DESIGNED FOR SAME COST PER KILOWATT

In units of 60,000 kw. or larger, the three-cylinder cross-compound construction employing one high-pressure and two low-pressure elements, possesses the advantages of high efficiency and reliability without employing excessively large structures and has greater flexibility than is possible with either of the other constructions. This flexibility, enabling the high-pressure element to operate with either low-pressure element, or either of the three elements to operate alone, admirably adapts it for use in systems not yet large enough to permit employing a single unit of so large capacity. These units may be provided with a control mechanism by means of which either of the elements may be taken out of service either automatically or manually, through operation of circuit-breakers or automatic stop governor, and the remaining ones will continue to operate, carrying loads up to the maximum ratings of their generators. The low-pressure elements, when operating on high-pressure steam direct, may be made to carry loads for short periods considerably in excess of the rated capacities of their generators.

In Pennsylvania there is a fire that has been burning continuously for sixty years. It started in a coal mine and spread to surrounding deposits. How much fuel it has wastefully consumed cannot be even approximately estimated. It is said that more than one million dollars has been expended in efforts to extinguish the fire, all in vain. Now another attempt is to be made. The plan is to strip the top of the mountain which overlies the burning section, remove veins of coal that lie in the path of the fire, and thus "starve" it. The area to be stripped is about a mile long and 400 yards wide. The stripping will have to be of an average depth of forty feet.—*Detroit News.*



Keep Coal out of the waste pile and waste out of the Coal Pile

OF the earth's abundance only those things that procreate are subject to increase. Fixed in the earth is the great storehouse of mineral wealth, and upon it we must depend for all time By no human skill may it be increased by so much as one tiny atom. The total amount is inwrought and immutable. Mine, either by surface operation or deep-driven incision, and instead of nourishing and curing the wound nature leaves it stark. Elsewhere and yet elsewhere must the stuff of life be taken out and carried away. Let us not waste this stuff Whether it be heat-giving, power-giving coal or something less essential to happiness let us save at every step The Pennsylvania Crusher Company intends to do its full share and seeks to work with those who are interested in

keeping coal out of the waste pile and waste out of the coal pile

FUEL-CONSERVATION WALL HANGER

An attractive wall hanger in two colors, about 10 by 12½ in., which is reproduced in miniature here, has been issued by the Pennsylvania Crusher Co., Stephen Girard Building, Philadelphia, Penn. It is intended for free distribution and anyone interested in fuel saving can obtain a copy on application to the company.

American Engineering Standards Committee

IN HIS address, "Engineering and Industrial Standardization," delivered at the Midwinter Convention of the American Institute of Electrical Engineers, Feb. 20, 1919, President Comfort A. Adams outlined the purpose and machinery of the American Engineering Standards Committee as follows:

At present the work of standardization is carried on by numerous organizations each in its own field and with its own machinery, usually through a standards committee. But the fields overlap and the machinery differs largely in the different organizations. In many cases the committees are made up of men who do not realize that a standard must be not only rational and technically correct, but also acceptable to all those interested in its manufacture and use. The mere promulgation of a standard by any society, however powerful, does not make it a real standard.

Moreover, the fields of the several organizations overlap in large degree; there is much duplication of effort and confusion of result, and many of the standards promulgated are practically useless.

Coöperation between two or more organizations has been tried, sometimes successfully, but there was no recognized machinery of coöperation, no standard procedure, and confusion still reigns.

To meet this need there has been recently created an American Engineering Standards Committee whose purpose, organization and method of operation are outlined below:

The American Engineering Standards Committee was formed by joint action of five national engineering societies (American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers and the American Society for Testing Materials) called the "Founder Societies," to meet a long-felt need of some available and satisfactory machinery for the development of engineering and industrial standards, by the operation of which duplication would be avoided and coöperation between all interested organizations and Government departments secured; so that when a standard or group of standards is developed it will be acceptable to all concerned and therefore a real American standard. Moreover, as international standardization develops, there is imperative need for an authoritative national body to deal with the corresponding foreign bodies. National Engineering Standards Committees are already in operation in England, Canada, France and Holland, and others will undoubtedly be organized in the near future.

The American Engineering Standards Committee machinery now proposed for the development of standards is made up as follows:

a. The committee proper or the "Main Committee," with three representatives from each of the five "Founder Societies" and three Government departments, whose functions are chiefly those of an organizing, coördinating and steering committee.

b. "Sectional Committees," one for each group of standards, with representatives from all organizations or Government departments vitally interested in that particular group of standards, whose function is to prepare the standards in question under the direction of the most vitally interested organization known as the "Sponsor Body."

c. The "Sponsor Body" or "Body" may be one of the Founder Societies, a Government department, or one of the "Coöperating Societies" or organizations.

d. Under "Coöperating Societies" it is intended to include all organizations interested in the production of standards and willing to coöperate.

The procedure is:

1. When the development of a particular group of standards is proposed, the main committee assigns the work to the appropriate organization as "sponsor," or if the situation seems to indicate that more than one organization is equally interested, to these organizations as "joint sponsor."

2. The sponsor then appoints the sectional committee subject to the approval of the main committee. The purpose of this approval is merely to assure the comprehensive representation of all the interests involved. Complete records of all interested organizations and of their standardization work and connection will be kept on file and properly classified in the office of the main committee. The main committee or its secretary will thus be able either promptly to suggest the proper representation to a sponsor on request or to approve or amplify the representation as provisionally proposed by the sponsor.

3. After a group of standards has been prepared and accepted by a sectional committee, it is submitted to the sponsor body for its approval and then to the main committee with a full report of its history. When approved by both the sponsor body and the main committee, the standards in question become American standards.

4. When the report of any sectional committee is being considered by the main committee, three members of that sectional committee are invited to sit with the Main committee to report, discuss and vote on the standards in question as if they were regular members of the committee. Thus each sectional committee, and therefore usually each sponsor body, will be represented on the main committee when standards in which they are interested are discussed.

5. The scrutiny of a standard by the main committee is to make sure that the proper procedure was pursued (that is, was prepared by a comprehensively representative sectional committee), that the vote of acceptance was nearly enough unanimous, and that the standard is consistent with other related standards. Consideration is also given to international relations; but the main committee is not supposed to pass upon the details, as it is obviously impossible for a moderate-sized workable committee to cover the details of all parts of the field.

6. After approval by the main committee the standard is published by the sponsor body with the statement that it has been approved by the American Engineering Standards Committee and labeled "American Standard," with the appropriate descriptive title.

Briefly summarized this procedure is as follows: Standard assigned by main committee to sponsor body; sponsor body appoints a thoroughly representative sectional committee, subject to approval of main committee; sectional committee prepares standard and submits to sponsor body, which then submits the standard with its approval to the main committee. The standard is then published by the sponsor body and labeled, "American Standard."

The machinery thus provides for absolutely comprehensive coöperation, eliminates overlapping and duplication of effort, and yet does not undesirably restrict the initiative of the several coöperating societies.

With proper support and the coöperation of all interested organizations, it should contribute largely to the industrial development of the country.

Moreover, it should be a potent factor in promoting international standardization and foreign commerce.

In the broad sense international standardization means a common industrial language and the removal of one of those barriers which tend to separate nations and to give rise to misunderstandings.

The more of these barriers we can remove, the more likely we are to attain that lasting peace which the world longs for.

Under a final agreement on the oil leasing bill more than 50,000,000 acres of Government-owned oil, gas, coal, phosphate and sodium lands in Western states and Alaska will be opened for development. The land will be subject to a royalty, which in the case of oil and gas will not be less than one-eighth of the gross value of the production.

Congress has authorized the expenditure of $100,000 for lignite investigations by the Bureau of Mines and a survey is being made to determine where the experimental plant shall be located.

Midwinter Convention of the American Institute of Electrical Engineers

The American Institute of Electrical Engineers held its seventh annual midwinter convention, Feb. 19, 20 and 21, in the Engineering Societies Building, New York City. The first session, Wednesday afternoon, was a joint meeting of the American Institute of Electrical Engineers and American Institute of Mining Engineers. Electric Welding was the subject discussed at this session, five papers being presented.

S. W. Miller presented a paper, "Path of Rupture in Steel Fusion Welds," in which he pointed out the results of a series of tests on welds made by various processes in different kinds of iron and steel. These tests consisted very largely of a photomicrograph study of both gas and electric welds subjected to bending after being polished and etched. In the paper are given 82 of these photomicrographs, some of them of 1200 diameters. The etching was done with a 2 per cent. solution of nitric acid in absolute alcohol and has been carried far enough to show the grain boundaries. The object of the etching was to locate the grain boundaries, therefore no attention was paid to the structure of the heavy etchings unless they were checked by normal etching with both picric and nitric acid.

The author expressed the opinion that in the present case it is difficult to describe what occurs during the testing, therefore he has given most of the information with photographs. The conclusion reached is that the first evidence of strain in any weld is at whatever visible defects may exist in the weld, such as films of oxide around the grains or around small particles of metal, as in electric welds. However, this is hard to prove by photographs. In electric welds the structure is usually more columnar than in gas welds. It would appear that the rapid cooling of electric welds is responsible for this and that the slower cooling of gas welds probably makes the grains more nearly equiaxed.

All brittle welds resemble one another in that the structure is more or less columnar and that they contain impurities. According to the usual understanding, during the solidification or cooling from high temperatures of a metal, impurities are rejected to the grain boundaries. The author is of the opinion from rough tests he has made that the brittleness in gas welds at least can be removed by heat treatment. However, he is not so sure about electric welds, since their heat treatment, at least in an ordinary way, does not remove the line structure; in many cases the lines lie either on or very close to the grain boundaries.

The quenching of electric welds appears to produce an entirely different structure; the grains lose their columnar nature and the lines disappear. It seems clear that the only way to account for the brittleness of welds is to assume that it is caused by films of material at the grain boundaries, the nature of these films differing in different welds.

While the author questions whether anything but circumstantial evidence can ever be adduced for his belief in the presence of the films, the facts are that, under welding conditions, very thin films which are visible do exist; and that with welds containing impurities, the breakage is always at the grain boundaries where it is known the impurities collect. So he sees no reason to doubt their existence and believes that they are responsible for the brittleness of such welds.

In a paper, "Micostructures of Iron Deposited by Electric Arc Welding," read by George F. Comstock, the author adds some further discussion on a paper, "Some Structures in Steel Fusion Welds," by S. W. Miller, presented before the American Institute of Mining Engineers, February, 1918. This paper is also a photomicrographic study of electric welds.

"Welding Mild Steel," a paper presented by H. M. Hobart, deals with investigations undertaken by the Welding Research Subcommittee of the Welding Committee of the Emergency Fleet Corporation. An abstract of this paper will appear in an early issue of *Power*.

A brief review was given of what had been done in substituting welding for riveting in ship construction, by S. V. Goodall in a paper, "Welding, a Process in Ship Construction." The author points out that the Welding Committee of the Emergency Fleet Corporation has found by actual experience that a labor saving of at least 60 per cent. has resulted from the substitution of arc welding for riveting on minor parts of ships where structural strength is of little concern. The conclusion is reached that the best line of approach appears to be to build up a staff of thoroughly skilled welders, to gain experience by the adoption of welding on minor parts, to proceed cautiously in the extension of the process to more important members, not to expect a great saving in time and cost immediately, but to persevere, not necessarily toward the rivetless ship, but toward a vessel in which the employment of both processes of riveting and welding is so adjusted that more riveting or more welding could be done only at greater cost.

O. H. Escholz, in a paper, "Fusion in Arc Welding," called attention to such characteristics as penetration and overlap, peculiar to the metallic-electrode arc-welding process, which facilitate visual inspection and discussed briefly the effect of arc length, welding procedure, electrode material, arc current and electrode diameter upon these characteristics. An abstract of this paper will be published in an early issue of *Power*.

Comfort A. Adams, president of the American Institute of Electrical Engineers, who presided at the meeting, gave a brief summary of the work done by the Welding Committee of the Emergency Fleet Corporation, of which he is chairman. The speaker told how ever 20 tons of steel plates had been used in making the welding tests of the research committee. He said that the advance made in electric welding during the last year had been as great as that of the preceding ten years and announced that a new welding organization is being started to continue the work begun by the welding committee and to carry on investigations necessary for the advancement of all classes of welding.

In discussing the various papers on welding, H. A. Horner spoke of the necessity of having skilled welders and told how those of the Emergency Fleet Corporation were instructed. Mr. Horner expressed the opinion that the outlook for producing skilled welders from the laboring classes were not very promising and that few exceptionally skilled welders were produced by the training given the class of men the Emergency Fleet Corporation had to instruct. The speaker said that the best welders are men of a very sensitive nature and that if conditions were not favorable for producing good welds they would stop work. To produce good welds the welder must concentrate all his attention upon his work and he cannot be expected to do satisfactory work if he has to dodge hot rivets.

W. L. Merrill took just the opposite view to what Mr. Horner expressed regarding training unskilled laborers to become skilled welders. He said this was not only possible but had already been done. Speaking on spot welding, Mr. Merrill said that it was always possible to tell the character of the weld by an inspection of the surface of the weld, and that two spot-welding machines, each weighing 6 tons, had been built and successfully tested in ship construction.

It was brought out in the discussion that a system was under development whereby the quality of any weld could be determined without destroying the weld.

The part of the discussion of greatest interest to power-plant engineers was that by H. R. Woodrow on electric welding something over 10 miles of high-pressure steam line. This discussion is published on page 322 of this issue.

On Wednesday evening Dr. John A. Brashear delivered an exceedingly interesting lecture, entitled "An Evening with the New Astronomy." The lecture was illustrated with lantern slides, many of them showing what it was possible to see through the large telescopes, to the development of which Dr. Brashear has devoted a large part of his life. From the applause given the speaker by the audience that filled the auditorium, it was evident that they felt the doctor's efforts had not been in vain.

At the Thursday morning session President Comfort A. Adams addressed the meeting on "Engineering and Industrial Standardization." He discussed the importance of standardization and its dangers and indicated the comparative chaos that still reigns in most parts of the field of engineering and industrial standardization, not only in the standards themselves, but in the methods of creating them, and outlined the machinery proposed by the American Engineering Standards Committee to remedy this condition. The outline of the proposed machinery of the American Engineering Standards Committee is published in this issue on page 337.

After President Adams delivered his address two papers were presented: "The General Equation of the Electric-Circuit—III," by C. P. Steinmetz; and "Review of Work of Subcommittee on Wave-Shape Standard, of the Standards Committee," by H. S. Osborne.

Thursday afternoon was devoted to technical excursions to the Brooklyn Navy Yard, which approximately 200 members and guests visited; to the New York Edison Co.'s Waterside Station, the United Electric Light and Power Co.'s power station, the Interborough Rapid Transit Co.'s power station, the Electrical Testing Laboratories and the laboratories of Bell Telephone System.

A dinner-dance was held on Thursday evening at the Hotel Astor, which 375 members and their guests attended.

Two technical sessions were held on Friday. The morning session was held under the auspices of the Telephone and Telegraph Committee. Two papers were presented: "Aëro Telephony," by E. B. Croft and E. H. Colpitt, and "Theory of Transient Oscillations," by J. R. Carsons. The afternoon session was held under the auspices of the Electrophysics Committee. Three papers were presented at this session: "Ionization of Occluded Gases in High-Tension Insulations," by G. B. Shanklin and J. J. Matson; "The Dielectric Strength of Air Films Entrapped in Solid Insulation," by F. Dubsky, and "Abnormal Voltages in Transformers," by L. F. Blume and A. H. Boyajian.

The average attendance at the meetings was large and the convention closed with a total registration of 1001.

Illinois Chief Engineers Meet at Dunning

SINCE the recent consolidation effected by the present Governor under the Civil Administrative Code, the various state institutions of Illinois are tied more closely together and are under common supervision. All mechanical work, including operation, maintenance, repair and new construction is subject to the supervision of Fred J. Postel, a state officer bearing the title of supervising engineer. The chief engineers of the various institutions, having charge of mechanical work, are now, in a way, units of the organization, and as there are many operating features of common interest, they were called together at state expense to hold their first annual meeting at Dunning on Feb. 14 and 15. An interesting program had been prepared, there was lively discussion on topics pertaining to the work, and in one of the power plants of the institution demonstrations of boiler-room instruments including draft and CO_2 equipment and a recording pyrometer, were made. Twenty-three institutions under the Department of Public Welfare and five normal-school plants were represented. The attendance exceeded forty and the meeting was such a decided success that in all probability it will be made an annual event.

Acting as chairman, Fred J. Postel first called upon the director of the Department of Public Welfare, Charles H. Thorne, who greeted engineers and spoke of the value to be derived from such a gathering. Mr. Thorne was a great believer in placing the engineer where he belonged, at the head of the mechanical equipment, giving him full charge in order that he will take pride in his work, assume the responsibility and receive the recognition that is due him.

Joseph Harrington, formerly administrative engineer for Illinois, United States Fuel Administration, introduced an excellent talk on "Boiler Room Operation" by commending highly the attitude toward engineers Mr. Thorne was trying to develop. The engineer was coming into his own. The experience of last winter had opened the eyes of the public to his importance and a realization that his work calls for ability, resourcefulness and sound judgment.

Upon the assumption that the speaker were called in to make a report on the power plant of a state institution, he would first want to know the over-all efficiency, measured by the coal per kilowatt-hour, or if current was not generated, by the pounds of steam per pound of coal. Coal-weighing equipment then was the first essential. It is necessary to know the amount of coal used in each day's run and if done right the coal to each boiler should be weighed, so that any variation in economy might be traced accurately to the source.

How much steam is made with the coal is the next question. Its solution calls for a steam-flow meter. Feed-water weighing equipment would answer the purpose, but, owing to the various leaks from the boiler, the records would not give accurately the steam delivered to the mains. The installation of both meters is preferable as one tends to check the other.

With the two fundamental items determined, the next step is to record these data in a simple and comprehensive log, so that the figures can be analyzed and comparison made with past performance. Division should be made between the boiler and engine rooms so that variations in efficiency can be traced to the proper department and corrective measures applied.

To analyze boiler-room conditions, start with the coal. Its heat value should be known. If it is not practical to test each carload received, the origin of the coal can be determined and from data available a close approximation made of the heat value and the ash content. Then determine the rate of combustion per square foot of grate area. The amount of coal that can be burned economically per unit of draft is definitely fixed. Limitations of each furnace should be recognized unless it was desired to force the furnace at a loss of efficiency by passing fixed carbon to the ashpit. About 7 lb. of air per pound of carbon was all that could be forced through the fuel bed. Unless the balance needed were admitted over the fire or around the grate, it would have to be supplied mechanically.

Excess air is determined by the gas analyzer. CO_2 readings are the best indications of furnace efficiency available. It is a nice thing to have a CO_2 recorder on each boiler or at least one instrument in the plant that could be shifted from one boiler to the other. A recording instrument is needed, as the conditions in a furnace constantly vary. Where such an instrument is not practical the speaker advocated a gas sampling tank on each boiler that would draw a continuous sample and hold it for the hand analyzer.

Hydrocarbon losses were not determined by the Orsat. Heat balance tests showed that the difference between clean and smoky operation ranged from 3 to 5 per cent., the hydrocarbon rather than the carbon loss being responsible. Insufficient furnace volume was usually responsible. An increase in flame travel would better conditions. In the old days boilers of the B. & W. type were set with the bottom of the front header 4 to 6 ft. above the floor. The furnaces were always smoky and efficiencies ranged from 55 to 60 per cent. Today boilers are set 12 ft. above the floor and for heavy loads 15 ft. is not too much. The furnace should be proportioned so that the flame does not reach the tubes. A cubical content of 12 cu.ft. per square foot of grate area, as compared to 6 cu.ft., the old standard, is not too much. With powdered coal volumes of 30 cu.ft. per square foot of grate have been reached, so that the furnace was as large as the boiler itself. Securing the proper furnace volume is only half the problem. To get the necessary flame travel the height vertically must be considered. If the boilers cannot be raised, a dutch oven is the next best thing to secure length of flame travel.

The loss from unclean heating surface might easily prove serious. There were two sides; on one soot collected and on the other, scale. Excessive loss from either was readily preventable. As the loss due to scale increases as the square root of the thickness, the first thin layer does the greatest damage. The speaker was not a believer in boiler compounds. The scale-forming matter should be precipitated before the water reached the boiler. A water-purification system always paid. To prevent scale formation in the boiler was entirely feasible and economical.

Soot was one of the finest insulators known and allowing it to collect might be compared to wrapping the tubes with asbestos paper. For its removal the speaker liked to see mechanical blowers rather than the steam lance; for what the operator can do easily, he will do more readily. A rise of 25 deg. in the flue-gas temperature means approximately a loss of 1 per cent. in efficiency.

For the average six-boiler plant, the instruments considered essential were a coal scale, steam-flow meter, gas-sampling tank and Orsat, flue-gas temperature recorder and a draft gage on the furnace and uptake. An operator could get by without more elaborate equipment, although there were refinements that might prove desirable.

In the discussion the accuracy of the steam-flow meter was questioned. More confidence was placed in the feed-water meter. The use of rain water and distilled water for makeup and the causes of pitting were discussed.

Oil carried over with the exhaust steam into a vacuum heating system and thence back to the boilers was a trouble that had been experienced. Due to the vacuum the oil had volatilized and got past the separator. The use of oil that did not volatilize readily and the insertion of a valve on the supply line that maintained pressure on the separator relieved the trouble.

On the basis that the appropriation for instruments was limited, it was Mr. Harrington's contention in reply to a question as to what instruments were most essential, that the coal must be weighed and the water measured.

Formation of slag on the lower tubes of a water-tube boiler had been prevented by the application of graphite and the use of a hand lance in addition to the mechanical blower. Reference was made to the perfection of mechanical elements to take care of the slag. Increasing the width of the throat between the end of the arch and the bridge-wall had lessened the slag trouble by reducing the velocity of the gases.

In removing soot excellent results had been obtained by the use of salt. The salt should be absolutely dry and not too coarse and should be placed on the hottest part of the fire. Tubes had been used to blow it to the proper location in the furnace. In one case it had been used in conjunction with a mechanical blower, with good results.

The use of a damper regulator that threw the damper fully off or on was not favored as it was seldom that the fuel bed was in a right condition for either extreme. A damper regulator that floated with the demand for steam was the better type to employ.

Friday Afternoon Session

At the afternoon session Prof. H. H. Stoek, of the University of Illinois, talked on coal storage and some of the things that had been discovered in a study of over 100 fires during the past season. Coal should be stored as near as possible to the point where it is to be used. The mines, the railways and the consumers should share the expense of storage as each is benefited thereby. From the storage of coal there is very little lost in heat value.

As to the kind of coal that can be stored safely, almost any bituminous coal under certain conditions will give trouble from spontaneous combustion. This trouble depends not so much on the coal itself as the size and the way in which it is stored. Most of the trouble from fires develops from run-of-mine coal, a mixture of fine and coarse particles. The finer the coal the greater the area exposed to the air and the greater the oxidation. With the coarse coal on the outside of the pile as it usually is, allowing air to get to the fine dust at the center, trouble is almost sure to develop. Lump or sized coal that is clean and does not contain much fine coal can be stored safely. Screenings have been stored by keeping the pile compact and pressed down to exclude the air. In over 100 fires in Chicago that have been studied during the past season, 55 per cent. were in mine-run coal and 33 per cent. in screenings. It did not seem to make any difference whether the piles were under cover or in the open, as the division on this basis was exactly even.

There were two ways to cool to prevent spontaneous combustion. One was to ventilate the pile thoroughly, supplying enough air to carry off the heat and the other was to admit no air at all, so that there could be no oxidation. The latter condition might be obtained by storing under water or in finely packed piles. One of the safety rules for storage was to limit the height of the pile to 8 or 10 ft. The temperature of the piles should be watched closely and when it reached 150 deg. preparations should be made to move it.

Pyramid piling usually brought the big lumps to the bottom and the sides, and the fine coal to the center and top. This was the worst condition possible, as air was readily admitted through the coarse coal and fires started readily at the junction point between the fine and coarse coal. If it is necessary to store mixed coal it should be piled in even layers.

In the discussion following it was brought out that fires were more likely to develop in coal that was brought in wet. In putting out fires a brine solution seemed to be more effective than water.

Prof. S. S. Parr, also from the University of Illinois, made a plea for uniform sampling of coal. He distributed printed instructions on equipment to use and method of sampling.

In the evening F. D. Whipp, fiscal supervisor, gave an interesting talk on state institutions, showing the activities and giving statistics on the cost of operation. The Natonal Tube Company's reel on the manufacture of iron and steel pipe, showing the progress from the ore in the ground to the finished products, was also presented.

Saturday Morning's Session

On Saturday morning F. J. McCullough, assistant supervising engineer, gave an interesting talk on the leaks and wastes in state institutions that should be stopped. In his opinion the leaks and wastes were better indications of an engineer's ability than an examination.

The remainder of the day was taken up by discussion of operating problems. The utilization of waste heat in tunnels was recommended. The engineers were advised to allow the air for one or two buildings to flow through the tunnels and take up the heat that was radiated from the steam and hot-water piping. More attention should be paid to fresh air in the buildings, and to keep down the power required by the fans in cold weather part of the air should be recirculated. Vacuum heating systems could be laid out so that the returns would almost come back by themselves to the plant. The vacuum should not exceed 6 to 8 in. at the pump, giving about 3 or 4 in. at the building. A higher vacuum was disadvantageous as it would cause more leakage of air into the system and add to the work of the pump. It was pointed out that an oil separator should have at least 6 ft. of straight pipe ahead of it and a run of 10 ft. was better practice.

In two or three institutions in the domestic hot-water system an open heater had been substituted for a closed heater and the water circulated by means of a pump. The open heater was much easier to clean and as the steam from the pump was exhausted into the heater, there was very little loss. Some trouble had developed from scale forming in the pump.

By properly regulating the humidity, considerable saving could be effected in the steam required for heating. One of the simplest and most inexpensive methods was to introduce a steam jet in the air supply to the building when the indirect system of heating was employed, and in the case of direct radiation, to introduce a pet-cock in the riser near the ceiling of the various rooms.

Furnace Fractures While Bulge Is Being Forced Back

The report of the Manchester Steam Users' Association for 1917-18 contains an account of furnace fracture during the process of setting back a bulge that had formed. Usually, if a bulge is slight, it is forced back cold; but if it is deep, it is heated, driven back and finished off cold. In the instance referred to, a bulge had been set back and was being finished off cold, when suddenly a piece of metal about 10 in. in diameter broke out of the furnace plate. The condition at the edges of the break left no doubt that the fracture was instantaneous.

In explanation of this action, it is pointed out that wrought iron and mild steel have a common critical temperature, usually called blue heat, at which the metal is in a rotten condition and usually breaks if bent. If the bending is stopped before either breakage or cracks occur and the sample is laid aside for a short time and the bending is then continued, a fracture is almost certain to occur.

In the light of this explanation, the accident to the furnace plate is understandable. The center of the bulge was heated red hot for the setting-back operation, and there was a circular zone in which the metal was at a blue heat. The operation was successful, but the next day it was thought that improvement could be made and the ram pressure was again put on, this time on the cold plate, with the result that fracture occurred along the line of the blue-hot zone. The inference is that if a bulge is heated when being forced back, it should be reheated after the operation is finished.

Compromise on the Administration Water Power Bill

After what appeared to be an almost hopeless deadlock, the House and Senate conferees on the Administration water-power bill a few days ago reached a compromise agreement, which provides that the administration of water powers shall be vested in a commission composed of the Secretaries of War, Interior and Agriculture, who will be authorized to grant fifty-year permits for the use of water power. One of the principal points of disagreement was the recapture clause, the House committee insisting on the payment of the net investment, while the Senate stood out for payment on the basis of fair value. The recapture clause in the compromise bill provides that the Government upon expiration of the lease may take over the property by payment of an amount equal to the net investment provided this sum does not exceed the fair cash value.

The question of compensation to be paid the Government for the privilege of the grant was another matter of controversy, but now this matter is to be left in the hands of the commission.

It was hoped that the amended bill would reach the floor of the House and the Senate in the closing days of the session, and it is possible, although not altogether certain, that the bill may be passed before final adjournment.

Study the work you are doing. When a man gets it into his head that there is a right way and wrong way to handle every job, he has taken the first step toward making his work interesting.

Personal

W. G. Burrell, who has been in the employ of the Wellman-Seaver-Morgan Co. for the last 21 years, was elected second vice president of the company at its recent annual stockholders' meeting.

H. P. Rust, formerly with Viele, Blackwell & Buck, engineers, New York, and until recently with the engineers of the Canadian army, has accepted an appointment with Wm. Cramp & Sons Ship and Engine Building Co., Philadelphia, Penn., as engineer of plant.

W. S. Quigley, president of the Quigley Furnace Specialties Co., Inc., sailed for Liverpool on Feb. 15, for the purpose of further developing European connections of his company. He will spend several weeks in England, France and Italy and visit the plants installing the Quigley system for preparing and burning pulverized coal and lignite.

Lieut. A. G. Kessler, U. S. N. R. F., who for the last six months has been in charge of the gun division of the Bureau of Ordnance, Navy Department, has been released from active duty in the Naval service and has become vice-president of the General Ordnance Co., Derby, Conn., and of the National Tractor Co., Cedar Rapids, Iowa, in charge of purchasing and production at both plants. Mr. Kessler was formerly general manager of the Lakeside Forge Co., Erie, Penn. The New York offices of the National Tractor Co. are at 512 Fifth Ave.

R. E. S. Geare has been elected president of the Mid West Manufacturing Co., recently incorporated. Mr. Geare is well known to the construction and power plant field in Chicago and the Middle West because of his active representation of the T. L. Smith Co., Manistee Iron Works Co., Geare & Co., and others, which work he will still continue. The Mid West Manufacturing Co. has located its factory in Chicago, with general offices in the Old Colony Building. It has acquired the sales and manufacturing rights of the "Continental" chain-grate stoker from the Manistee Iron Works, and the "Chaingrip" pipe vise and tools from the Gerolo Manufacturing Co. In addition to this the manufacture of special machines, tools and dies; rebuilding of construction and power plant machinery together with the installation of such machinery will constitute an important part of the new company's activity.

Engineering Affairs

The American Association of Engineers will hold its annual convention at the Hotel LaSalle, Chicago, May 13-14.

The American Institute of Electrical Engineers will hold its three hundred and forty-eighth meeting in Boston, Mass., Mar. 14.

The National Electric Light Association will hold its annual convention at Atlantic City during the week beginning May 19, and plans are now being perfected for making it all that the big pre-war meetings were. The customary exhibition, which has not been held since 1916, will be one of the big features at the coming convention.

The Manufacturers Aircraft Association, Inc., will hold its first aëronautical exposition in Madison Square Garden and the 69th Regiment Armory, New York City, March 1-15. Every phase of the industry will be represented and the exposition will have a distinctly international character. It is expected that the Division of Military Aëronautics will have available for display an interesting collection of war trophies; and both the Navy and Army have prepared comprehensive exhibits of mechanical appliances and scientific instruments called into being by the remarkable development of aërial navigation during the war.

Miscellaneous News

The New Jersey Board of Boiler Rules will hold a public hearing at the State House, Trenton, N. J., on Thursday, Mar. 20 at 2 p. m. for final consideration of adoption of the recently revised A. S. M. E. Boiler Code covering "New Installations, Part I, Section I, Power Boilers."

Business Items

The Dearborn Chemical Co.'s Indianapolis (Ind.) office is now back at 312 Traction Terminal Building.

The Pulverized Fuel Equipment Corp. has recently been organized for the purpose of taking over the business of the Locomotive Pulverized Fuel Co., and to broaden the activities of the latter to cover the central power station, metallurgical and industrial fields. The head offices are at 30 Church St., New York City, with Canadian office in the Transportation Building, Montreal.

Trade Catalogs

The Chas. A. Schieren Co., New York City, has issued a new Price List which differentiates the various brands of Schieren beltings by markings, grades and weights, and enables the buyer to select a belting to meet his specifications.

The Green Fuel Economizer Co., Beacon, N. Y., has issued a 63-page Bulletin No. 151, illustrating and telling all about "Green's" economizers. A catalog of useful information for all who have economizers in their charge.

The Chas. A. Schieren Co., New York City, has issued an attractive booklet, with artistic colored illustrations on "The Story of Schieren Beltings." The business of tanning hides and manufacturing the leather into belting is treated simply and fully, in a way that any layman can understand.

Modern Methods of Ash Disposal. American Steam Conveyor Corp., Chicago. Pages, 160, 7½ x 10 in. Fully describes the four principal classes of ash-disposal systems, giving the advantages and disadvantages of all the various methods. Also illustrates typical installations and designs.

The Graton & Knight Manufacturing Co., Worcester, Mass., has gotten out a very finely illustrated catalog in two colors, showing the different processes of belt making from the receiving of the hide right through to the finished belt. It consists of 124 pages with a special three-page insert of the factory. It not only illustrates and describes the different products made by this company, but shows what can be accomplished for the manufacture of high-grade leather belting and leather specialties. The belting section fully explains the characteristic qualities, the particular differences and the capabilities of the different brands of belting. It also embodies mechanical rules, tables and other information that should be of value in determining the most efficient belt for any drive or in assisting with other transmission problems. The Graton & Knight Manufacturing Co. will gladly furnish anyone interested with a copy of this catalog.

New Construction

PROPOSED WORK

Vt., Bristol—The Hortonia Power Co., Brandon, plans to build an extension to its hydro-power plant here. J. M. Forst, Gryphon Bldg., Rutland, Gen. Mgr.

Mass., Holyoke—The School Board plans to install a steam heating system in the 2-story school building which it plans to build. Total estimated cost, $275,000. G. P. B. Alderman & Co., 437 High St., Arch.

Mass., South Boston—The Bureau of Supplies & Accounts, Navy Department, Washington, D. C., will receive bids until Mar. 18 for installing 2 air compressors at the Navy Yard here. Schedule No. 3788.

R. I., Providence—The Board of Contract & Supply is having plans prepared by J. H. Gainer, Engr., City Hall, for the construction of a central heating plant.

Conn., Norwalk—The Norwalk Realty & Improvement Co., c/o M. N. Mayehoff, 31 West Ave., plans to install a steam heating system in the hotel which it plans to build on Wall St., on the site of Old Royal James Inn. Total estimated cost, $100,000. G. F. Shepard, 14 Kilby St., Boston, Mass., Arch.

N. Y., Mohawk—W. W. Wotherspoon, State Supt. of Public Works, .Capitol, Albany, is having plans prepared for the construction of a hydraulic power plant here.

N. Y., New Rifton—The Hudson Power Corp., c/o Kingston Gas & Electric Co., Kingston, has had plans prepared for the construction of a power plant on the Walkill River, here. J. G. White Engineering Corp., 43 Exchange Place, New York City, Engr.

N. Y., New York—The Swartout Realty Co., c/o Ames & Co., 26 West 31st St., will install a steam heating system in the 2-story, 100 x 171 ft. garage which it plans to build on Lenox Ave. between 110th and 111th St. Total estimated cost, $200,000. B. M. Levitan, 7 West 45th St., Arch.

N. Y., Syracuse—The Department of Education will install a steam heating system in the 3-story, 100 x 150 ft. school which it plans to build on Madison and Walnut Ave. Total estimated cost, $230,000.

N. Y., Tonawanda—The Republic Light, Heat & Power Co. plans to build an electric-lighting-plant here.

N. Y., Wards Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install an electric conduit and switchboard here. Estimated cost, $7500.

N. Y., Watervliet—The Ludlum Steel Co., Spring St., will build a 1-story boiler house.

N. Y., Wellsville—The Pure Carbon Co. plans to build a boiler house here.

Penn., Bethlehem—J. Osborne Hunt, Arch., 114 North Montgomery St., Trenton, N. J., will receive bids about May 1 for the construction of a 2-story, 60 x 200 ft. factory and a 1-story, 50 x 75 ft. power plant for the Travelers Tire & Rubber Co., 819 North Broad St., Philadelphia. Estimated cost, $500,000. Guy DeLee Rigandiere, Pres.

Penn., Honesdale—The Consolidated Heat, Light & Power Co., 110 7th St., plans to build an electric power plant here. Estimated cost, $50,000.

Penn., Meadville—The Meadville Malleable Iron Co., Kerrtown St., plans to build a 1-story, 45 x 50 ft. power plant. Estimated cost, $10,000.

Penn., Oil City—The city plans to build an addition to the boiler house. Estimated cost, $45,000. W. W. Holt, City Clk.

Penn., Philadelphia — The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install pumping equipment in the Naval Base, here. Specification No. 3816.

Penn., Philadelphia—Clark & Craighead, 1736 North Broad St., will install a steam heating system in the 2-story, 100 x 200 ft. garage, store and office building which will be built here. Total estimated cost, $150,000.

Penn., Philadelphia—The Philadelphia Electric Co., 1000 Chestnut St., plans to improve its plant. A. J. DeCamp, Mgr.

Penn., York Haven—The York Haven Water & Power Co. has retained Gannett, Seelye & Fleming, Engrs., 204 Locust St., Harrisburg, to make investigations and submit report for improving and enlarging the 20,000 hp. hydro-electric power plant. W. L. Mann, Gen. Mgr.

D. C., Washington—The Bureau of Supplies & Accounts, Navy Department, will receive bids until Mar. 18 for installing a 10-hp. motor and controller at the Navy Yard here. Specification No. 3787.

Ala., Union Springs—The city voted in favor of a $10,000 bond issue for improvements to its electric-light plant. Address the Mayor.

Ohio, Alliance—The city plans an election March 18 to vote on a $200,000 bond issue for the construction of an electric-light and power plant. Wade Shietler, City Engr.

Ohio, Cleveland—The East 9th St. Euclid Co., c/o C. H. Beardsley, East 9th St. and Euclid Ave., will install a steam heating system in the 8-story, 70 x 163 ft. office building which it plans to remodel. Estimated cost, $100,000.

Ohio, Cleveland—J. L. Free, 1005 Prospect Ave., will install a steam heating system in the 2 story, 80 x 200 ft. mercantile building which he plans to build on Prospect Ave. and East 21st St. Max Dunning, 1005 Prospect Ave., Arch.

Ohio, Cleveland—The Rialto Amusement Co., c/o P. E. Essick, Stork Theater, West 85th St. and Lorain Ave., will install a steam heating system in the 2-story, 70 x 175 ft. moving picture theater which it plans to build. Total estimated cost, $150,000.

Ohio, Jackson Center—The City Council plans a $15,000 bond issue for public improvements, to include the construction of a lighting plant.

Ohio, Orville—The City Council voted in favor of bond issue of $20,000 for improving and enlarging the lighting plant.

Mich., Detroit—The Holley Carburetor Co., 145 East Willis Ave., plans to build a 23 x 44 ft. boiler house and install separate boiler for heating, forced feed boiler and pump, also motors for power in connection with the factory which it plans to build on Epworth Blvd. and Vancouver St. A. Kahn, Marquette Bldg., Arch.

Mich., Kinde—Bids will be received by W. Brinker, Village Pres., furnishing engine, generator, exciter, switchboard, pole line material, lamps, lamp posts and other material for the complete construction of an electric-light plant. Bonds for $10,000 will be sold for same.

Mich., River Rouge—The Ford Motor Co., Highland Park, plans to build a 2-story, 40 x 80 ft. sub-station and transformer house.

Ill., Chicago—J. S., H. C., and H. Phipps, 787 5th Ave., New York City, plan to build a boiler house in connection with the 1-story, 133 x 520 ft. factory which they will build on 47th and Whipple St. Total estimated cost, $225,000. Marshall Field Co., 22 East Washington St., lessee.

Ill., New Athens — The New Athens Milling Co. plans to rebuild its power house recently destroyed by fire. Estimated cost, $5000.

Minn., Hibbing—Bids will be received until Mar. 10 by C. Foster, Engr., c/o Hibbing Power & Light Co., for the construction of a 3-story, 104 x 158 ft. power house on Main St. A steam heating system will be installed in same. Total estimated cost, $150,000. Halstead & Sullivan, Palladia Bldg., Duluth, Arch.

Minn., International Falls—The city plans to build a pumping station.

Minn., Virginia—The city will receive bids about March 1st for the installation of a heating plant. Plans include the construction of a power plant. Noted Feb. 18.

Kan. Junction City—T. W. Dorn, City Clk., will receive bids until Mar. 10 for furnishing f.o.b. cars, a 50 kw. engine generator set.

Neb., Plymouth—The Beatrice Lighting Co., Beatrice, plans to build an electric-light plant here. B. H. Conlee, Mgr.

Mont., Cut Bank—J. Seal & Son, Great Falls, has applied to the City Council for a franchise to construct a small hydro-electric plant.

Mont., Duluth—The city plans to install a steam heating plant and mechanical ventilation system in the 4-story city hall which it plans to build on West 1st St. Total estimated cost, $1,000,000. L. A. Ayres, City Hall, Engr.

Mont., Miles City—The City Council will install an ash conveyor, 2 new boilers with stoker or self feeding apparatus and a 50-kilowatt generator with turbine motor in the electric-light plant. J. J. McGill, Supt.

Ark., Fort Smith—The Fort Smith-Van Buren Bridge District, 17 North 6th St., will soon award the contract for furnishing materials and reconstructing the power and light circuits on the Free Bridge. W. L. Winters, Engr.

Okla., Berry—The city plans to improve the waterworks and electric-light plant. Estimated cost, $100,000.

Cal., Seal Beach—The city will install a rotary pump and motor and 2 auxiliary booster pumps in connection with the sewerage system which it plans to construct. Total estimated cost, $40,000. Olmsted & Gillelen, 112 Hollingsworth Bldg., Los Angeles, Engr. A. Dyson, City Clk.

Que., Montreal—The Montreal Tramways Co., Ltd., 78 West Craig St., has had plans prepared for the construction of a substation on Cute St. Estimated cost, $400,000. B. Vernon, Royal Trust Bldg., Arch. W. Graves, Tramways Bldg., Ch. Engr.

Sask., Outlook—The Town Council is in the market for a 25 hp. engine and pump to force water to uptown cistern; lift of pump about 30 ft. Thomas G. Colby, Clk.

B. C., Esquimalt — The Department of Public Works, Ottawa, Ont., will receive bids until Mar. 18 for installing a complete heating system, two multitubular boilers, 60 in. diameter, 14 ft. long, electrically driven centrifugal boiler feed pump, etc., in the Military Hospital which it plans to build here. Total estimated cost, $150,000. R. C. Wright, Arch.

B. C., Smithers—The Canadian Pacific Railway, Windsor St., Montreal, Que., plans to build a power house and is in the market for machinery. Estimated cost, $25,000. A. Kilpatrick, Local Supt.

CONTRACTS AWARDED

N. Y., New York—M. A. Hoyt, 28 East 36th St., has awarded the contract for altering the office building at 40-44 Pine St. into a bank, to Marc Eidlitz & Son, 30 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $300,000.

N. Y., New York—The E. K. Stalle Estate has awarded the contract for the construction of a 30-story, 51 x 99 ft. office building on 42nd St. between Broadway and 7th Ave., to Subway Central Building Corp., 1482 Broadway. A steam heating system will be installed in same. Total estimated cost, $1,500,000. United Land & Stores Co., 44 West 18th St., lessee.

N. J., Elizabeth—The United States Leather Co., 856 Magnolia St., has awarded the contract for the construction of a 2-story, 115 x 220 ft. factory, to the Turner Construction Co., 244 Madison Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $200,000.

Penn., Pittsburgh—The Hein Co., 34 Isabella St., has awarded the contract for the construction of an additional 3rd and 4th story to its power plant, to G. Enzian & Co., 802 Madison Ave. Estimated cost $25,000.

S. C., Greenville—The General Asbestos & Rubber Co., 27 Cumberland St., has awarded the contract for the construction of a 1-story power plant, to the Fiske-Carter Construction Co. Estimated cost, $50,000.

Cal., Fresno—The San Joaquin Light & Power Co., H and Tulare St., will build a 20,000 hp., hydro-electric plant on the San Joaquin River near Macy Flat, to cost $1,750,000. Project includes diversion dam 70 ft. high, 100 ft. long at base and 450 ft. long at top, 2 mi. from present power house; 2 mi. tunnels and 2½ mi. concrete lined conduits to carry 600 sec.-ft. of water from dam to plant; 3 tunnels, largest 9000 ft. long, cut through solid rock; rock taken from tunnels will be used to build dam and penstock 800 ft. long; will also build roads to proposed power plant on the Kings River where 20,000 hp. plant will be built on Dinkey Creek; one plant will be built each year on Kings River, ultimate plans calling for development of about 200,000-260,000 hp. Complete cost to exceed $55,000,000. Work will be done by day labor.

PRICES—MATERIALS AND SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft. Lengths
Underwriters' 2⅝-in.	75c. per ft.
Common, 2½-in.	30%

Air	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.55	$0.40	$0.30

Steam—Discounts from List

First grade	25%	Second grade	35%	Third grade	40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	50%	Best grade	30%
Standard	40%		

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	30%	35%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure		Llist
For low-pressure heating and return lines	4-ply	58% off
	3-ply	60% off
	2-ply	62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5¼	7.2	8½	14½
Fiber or sponge	8	10	6	13	9	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4.75	3½ to 4½	5¼
Gear	4½	9	4½	7.5	7½	9
Car journal	22(gal.)	21 (gal.)	3½	4.9	9¾	8

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13¼ x 13¼	13¼ x 20½
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw in barrels	$1.50	$1.49	$1.65	$1.40	$1.66	$1.41
5-gal. cans	1.65	1.49	1.80	1.50	1.86	1.51

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13.00	14.50	11.25	11.50	13.00	11.00
25- and 50-lb. kegs	13.25	14.75	11.50	11.75	13.25	10.50
12½-lb. keg	13.50	15.00	11.75	11.00	13.50	10.75
1-lb. cans	15.00	16.50	13.25	13.00	15.00	13.00
5-lb. cans	16.00	17.50	13.25	13.50	16.00	13.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. carboys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel $\frac{7}{16}$ and smaller	40%	45%	45%
Tinned	30%	45%	40%

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:
New York....$6.60 Cleveland...$5.15 Chicago...$5.47 Pittsburgh...4.65

Coneheads, same sizes:
New York....$5.67 Cleveland...$5.25 Chicago...$5.57 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00	at Chester, Penn.
Chrome cement	net ton	65.00	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48	at Clearfield, Penn.
Magnesite, dead burned	net ton	37.50	at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	90.00	at Chester, Penn.
Silica brick	net ton	45–55	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL — Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	90.00	80.00	93.00	75.00	90.00
Commercial	42.00	50.00	18.50	22.00	15.00	30.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.50
Chicago	19.00	15.00

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

	Steel			Iron	
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼, and ⅜	47%	20½%	¾ to 1½	36%	20%
½	51%	36½%			
¾ to 3	54%	40½%			

LAP WELD

2	47%	34½%	2	29%	15%
2½ to 6	50%	37½%	2½ to 6	31%	18%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	43%	25½%	¾ to 1½	36%	21%
½	48%	35½%			
¾ to 1½	52%	39½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	45%	33½%	2	30%	17%
2½ to 4	48%	36½%	2¼ to 4	32%	20%
4½ to 6	47%	35½%	4½ to 6	31%	19%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	43%	27%	43%	26%	44.9%	29.9%
3½ to 3 in. steel lap welded	38%	23%	39%	23%	40.9%	26.9%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%. Cast iron, standard sizes, 10% off.

BOILER TUBES—The following are the prices for carload lots, f.o.b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in	37	3½ to 4½ in	15½
2½ to 3¼ in	27	3 to 3¼ in	+ 2
2¼ in	20½	2½ to 2¾ in	+ 4½
1¾ to 2 in	16	2 to 2¼ in	+ 19½
		1¾ to 1¾ in	+ 32

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in	$334	1½ in	$214
1⅛ in	274	2 to 2¼ in	184
1¼ in	264	2½ to 3¼ in	174
1⅜ in	214	4 in	194
		4½ to 5 in	214

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE—

B.&S. Size	Two Cond M Ft	Three Cond M Ft	Two Cond Lead M Ft	Three Cond Lead M Ft
No 14 solid	$104 00	$138 00	$164 00	$222 00
No 12 solid	135 00	170 00	211 00	290 00
No 10 solid	185 00	235 00	255 00	325 00
No 8 stranded	235 00	325 00	345 00	450 00
No 6 stranded	370 00	472 00	625 00	

From the above lists discounts are:

Less than coil lots	Net List
Coils to 1,000 ft	10%
1,000 ft and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0 40
12 to 50	.38
50 to 125 (bbl.)	35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft and Over	Galvanized 1,000 Ft and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜			$18 24	$19.38	$5.76	$6.12
½	$76.50	$81 60	18 24	19 38	6.72	7.14
¾	101 20	108 10	24 00	25.50	9.60	10 20
1	149 60	159 80	35 52	37.74	12 48	13.26
1¼	202 40	216 20	45 45	48 15	17.17	18 19
1½	242.00	258 50	60 60	64 20	21.21	22 47
2	325 60	347 80	111 11	117 70	28 28	29 96
2½	514 80	549 90	181 80	192 60	40 40	42 80
3	673 20	719 10	484 80	513 60	60 60	64 20
3½	837 20	892 40	1,070 60	1,134 20	80 80	85 60
4	1,013 70	1,079.10	1,237 25	1,310 75	101 00	107 00

5% cash 10 days.

From New York Warehouse—Less 5% cash

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
7/32	250	$0.05½	Coils 55% Off. Less coils, 40% off
¼	250	.06	
⅜	250	.09	
½	200	.12	
⅝	200	.15	
¾	150	.18	
1	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L	$0 11	T. P. to D. P. S. B	$0 24
D. P. M. L	.18	T. P. to D. P. T. B	.38
T. P. M. L	26	T. P. S. B	.33
D. P. S. B	19	T. P. D. B	.54
D. P. D. B	37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L	$0.33	$0 84	$1.68
T. P. M. L	48	1 20	2 40
D. P. S. B	42	1 05	
T. P. S. B	81	1 80	.
D. P. D. B	78	2.10	. .
T. P. D. B	1 35	3 60	. . .
T. P. to D. P. D. B	90	2.52	.

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No 18 cotton twisted	$22 00
No 16 cotton twisted	28 40
No 18 cotton parallel	25 00
No 16 cotton parallel	32 00
No 18 cotton reinforced heavy	35 00
No. 16 cotton reinforced heavy	42 00
No 18 cotton reinforced light	30 00
No 16 cotton reinforced light	36 00
No. 18 cotton Canvasite cord	29 00
No. 16 cotton Canvasite cord	35 00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp	100	$0.25
35-amp. to 60-amp	100	35
65-amp. to 100-amp	50	90
10-amp. to 200-amp	25	2 00
25-amp. to 400-amp	25	3.60
2-map. to 600-amp	10	5 50

600-Volt	Std. Pkg.	List
3 amp. to 30 amp	100	40
35 amp. to 60 amp	100	60
65 amp. to 100 amp	50	1 50
110 amp. to 200-amp	25	2 50
225 amp. to 400 amp	25	5 50
450 amp. to 600 amp	10	8 00

Discount	
Less 1-5th standard package	30%
1-5th to standard package	40%
Standard package	52%

FUSE PLUGS, MICA CAP—

0–30 amperes, standard package	$5 25 C
0–30 amperes, less than standard package	7 00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B Watts	Plain	Frosted	No. in Package	Mazda C Watts	Clear	Frosted	No. in Package
10	$0 35	$0 38	100	75	$0 70	$0 75	50
15	35	38	100	100	1 10	1 15	24
25	35	38	100	150	1 65	1 70	24
40	35	38	100	200	2 20	2 27	24
50	35	38	100	300	3 25	3 35	24
60	40	45	100	400	4 30	4 45	12
100	85	92	24	500	4 70	4 85	12
				750	6 50	6 75	8
				1000	7 50	7 75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

		Each
Hubbell, porcelain No. 5406,	standard package 250	$0 24
Hubbell composition No. 5467,	standard package 50	.32
Benjamin swivel No. 903,	standard package 250	20
Hubbell current taps No. 5638,	standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$13 00	$16 00	$18 00	$32 00
12	16 70	18 80	22 00	36 85
10	23 52	26 10	29 10	50 60
8	31 00	36 40	40 20	70 10
6	. . .	. .	62 00	
4	. . . .	. .	83 10	.
2	. . .	. .	122 40	. . . .
1	. . .	. . . . . .	161 30	. . .
0	. .	. . . . .	189 68	. . .
00	. . .	. . . . . .	230 00	. . .
000	.	. . . .	282 40	. .
0000	. .	. . . . .	345 50	.

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$15 00	$19 00	$38 40	$21 00	$16 00	$33 00	$12 00	$17.35	$29.90
10	22 65	29 05	58 25	27 20	31 00	69 00	23 10	23 60	52.80
8	31 95	39 20	78 65	38 00	42 00	78 00	32 10	41.10	. . . .
6	54 40	58 10			65 00	130 00	55 40	65 90	. . . . .
4	77 50	83 00		. . . .	93 00	.	72 65	90 00	. . . .
2	115 30	123 50	.	. .	140 00		115.00	129.50	. . . . .
1	150 05	161 20	.	. .	182 00	. .	155 60	168 50	. . . . .
0	. . . . . .	179 05	. . . . .	. . .	242 00		199.50	219.00	. . . . .
00	. . . . . .	243 35	.	.	290 00	.	245 50	261 50	. . . . .
000		296 65	.		360 00	.	299.50	317 00	. . . . .
0000	. . . . . .	361 50			435 00		356.00	378 50	. . . . .

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

⅛ In. or Pendant Cap.			⅜ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0 33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+ 20%
1-5th to standard package	+ 10%
Standard package	− 15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	45c. lb.
No. 18 B.&S. regular 1-lb. coils	47c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1 20 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0 42	$0 68	$1.02	$1 36
60	74	1 22	1.84	2.44
100	1 50	2 50	3 76	5.00
200	2 70	4 50	6 76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7 30
200	4.40	6.76	10 14	13 50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%

POWER

Volume 49 New York, March 11, 1919 Number 10

Big Words Humanized

ADAPTABILITY

means doing the next best thing in the handiest way.

EFFICIENCY

is knowing just how and fitting it to just when.

LOYALTY

consists in being decently considerate of the Boss.

RESPONSIBILITY

lies in having grit enough to risk a call-down.

OPPORTUNITY

is the same thing as being born lucky.

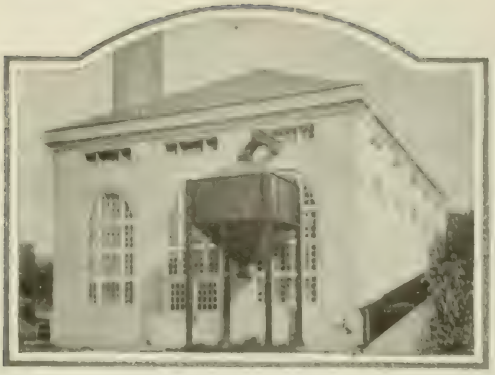
RELIABILITY

shows the capacity for staying put longest.

INTEGRITY

is the Sunday name for plain weekday honesty.

By FREDERICK MONON



Central Heating Plant

of the

Colorado State College

Some of the features of a steam-heating plant serving a group of college buildings scattered over twenty acres of campus, particularly coal- and ash-handing equipment and tunnels for steam and return lines.

STEAM for 42,000 sq.ft. of radiator surface in 26 buildings widely scattered over a campus containing 20 acres is the demand made on the central heating plant of the Colorado State Agricultural College, Fort Collins, Colo. The building that houses the boiler plant is shown in the headpiece. It is located fairly central to the group of college buildings and at the same time has good side-track accommodation from the main line of a railroad that passes through the college grounds.

As the college is a state institution dependent for support on appropriations made by the legislature, the building program was governed by the funds available and the equipment was installed in units instead of being completed at one time. At present there are two 234-hp. Stirling boilers in operation, but the building is designed to accommodate four more units of the same size and type.

Northern Colorado lignite slack is burned under the boilers on stokers of the chain-grate type. When the plant was first put in operation, the stokers were fed by hand with coal brought into the boiler room in small industrial cars; a later appropriation, however, enabled a Jeffrey mechanical coal-handling equipment to be installed.

A side track runs along the outside of the building, and the coal is delivered from the cars into a track hopper 12 ft. wide and 20 ft. long, made of ¼-in. plate. A standard plate feeder receives the coal from the track hopper and feeds it to a 24 x 24-in. single-roll crusher, as shown in Fig. 1. The crusher is used to reduce the size of lump coal whenever it becomes impossible to obtain enough slack.

The crushed coal is discharged into a ¼-in. steel spiral conveyor 12 in. in diameter and is carried up a slight incline for a distance of 30 ft., being then fed direct to the V-bucket elevator-conveyor shown in Fig. 2. This elevator-conveyor has 16 x 20-in. steel buckets with reinforced lips spaced 30 in. apart and has a capacity of 30 tons per hour. The vertical run is 23 ft. between centers and the horizontal run is 52 ft. between centers. The latter carries the coal to the hoppers in front of the boilers.

In working out the coal-conveying system it was necessary to take into account a future installation of steel storage bunkers which will be erected as soon as sufficient appropriations have been made. The driving mechanism of the coal-handling unit has been calculated on the basis of the completed installation and so is of such size and strength as to be able to care for the units to be added later. The installation at present uses wooden supports for the conveyor, but these are only temporary.

The ash-handling equipment, which is also of the Jeffrey type, is located in the basement; beneath the stokers is a horizontal drag chain conveyor 48 ft. between centers, as shown in Fig. 3, into which the ashes are discharged. It runs at a speed of 60 ft. per min. and has a capacity of 8 tons per hour. The ashes are carried along by the bottom strand in a cast-iron trough, the returning strand of chain being carried on angle-iron guides at the top. This conveyor discharges the ashes into a vertical elevator, Fig. 4, which passes up through the main boiler room to the ceiling and there empties the ashes into a spiral conveyor by which they are delivered to the steel storage bin outside. This bin, which can be seen in the foreground in the headpiece, is elevated so that a wagon can be driven under it and is provided at the bottom with a large clamshell valve through which the ashes may be discharged. The entire ash-handling unit is driven by one motor, so that all sections start at the same time.

The steam pipes and the return lines are installed in 4000 ft. of concrete tunnels, made in two different sizes, as shown by the sections in Figs. 5 and 6. The main tunnels are rectangular and are 5 ft. wide and 6 ft. 3 in. high, inside measurements. The floor and sides are not reinforced, but the roof is strengthened with triangle-mesh reinforcing wire. The walls and roof are 6 in. thick, except at wagon-road crossings, where they are somewhat heavier and more strongly reinforced. In two places the tunnels pass under the Colorado & Southern R. R., and at these points they were built very heavy to withstand the load due to traffic.

The smaller tunnels, or branches, are also rectangular, measuring 3 ft. wide and 4 ft. high inside, and the walls are 4 in. thick, the top alone being reinforced. At intervals in the small tunnels standard 24-in. cast-iron manholes are located, with ladders leading down into the interior. Tile drains are built under the floors of all the tunnels throughout their entire lengths. The pitch of the return pipes in the tunnel is such that all condensation can be returned to the boilers by gravity.

An interesting feature of the tunnel construction is the provision made for taking pipe and fittings into the tunnels. At the point where a sharp turn or corner occurs, each branch is continued on and upward at a

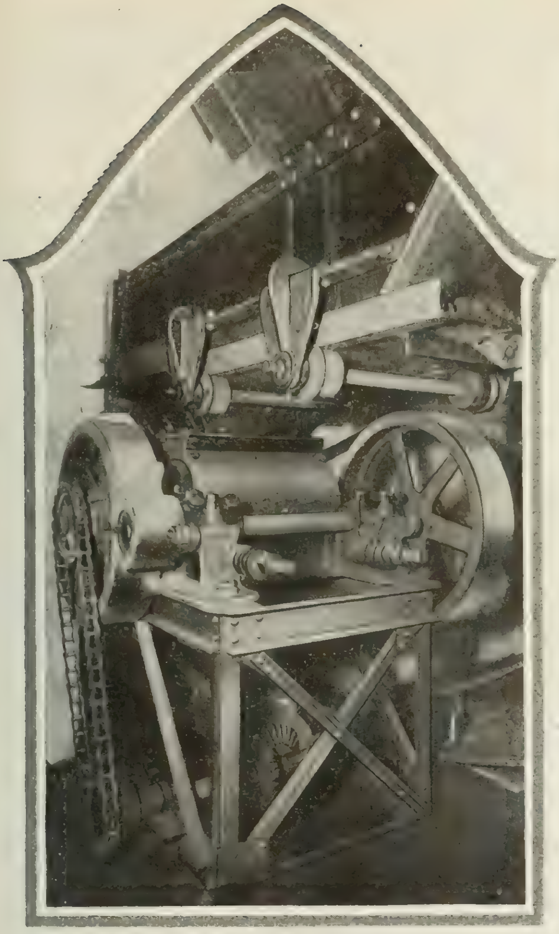


Fig. 1. Crusher for Lump Coal

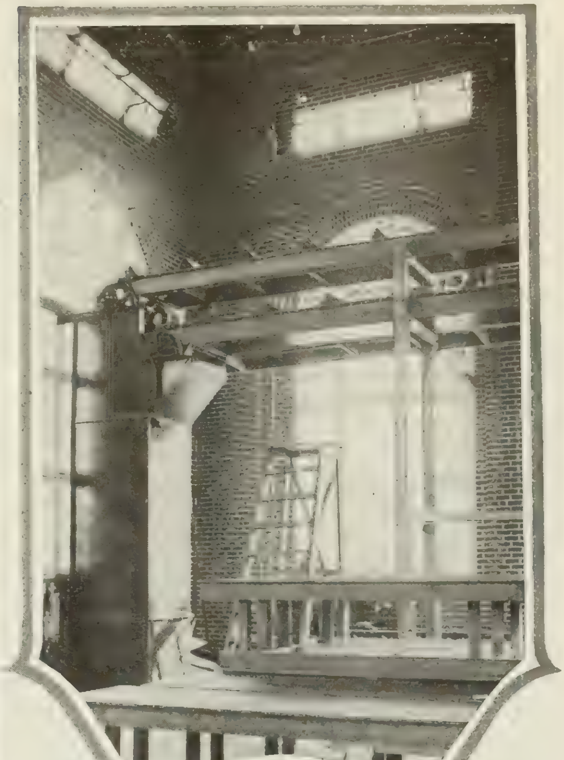


Fig. 2. Bucket Elevator-Conveyor for Coal

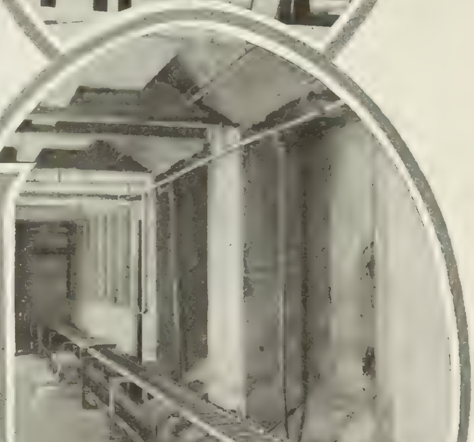


Fig. 3. Drag Chain Conveyor for Ashes

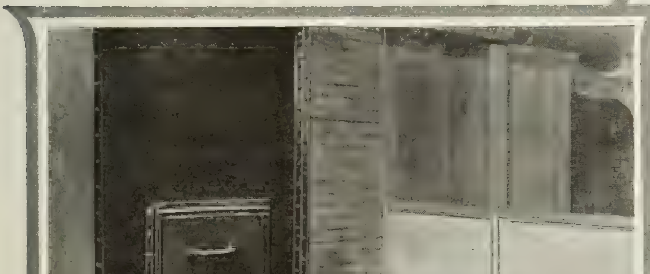


Fig. 4. Vertical Elevator for Ashes

gentle slope to the surface of the ground. These concrete runways leading to the outside enable piping and other material to be taken into or out of the tunnel on a small truck. The openings at the ground surface are closed by large steel doors.

All parts of the tunnels are lighted by electric lamps placed 12 ft. apart. They are arranged so that the entire tunnel may be lighted at one time, or, if desired, any section may be lighted alone. Thus, the workmen may light up the section ahead, as they go through the tunnel, and switch off the lights in that section when they pass to the next. One or more lamps may be removed and extension cords attached for the use of lamps in close-up work in any part of the tunnels.

In the large tunnels the pipes are laid on rollers held by cast-iron chairs carried by brackets. The brackets are bolted to vertical I-beams held in the concrete wall of the tunnel and are adjustable up or down on the I-beams. These beams were set in position in the forms for the concrete and when the concrete was poured and the forms removed they remained half embedded in the wall, spaced 12 ft. apart. All the pipes are free to go and come on the rollers except where they are anchored. Between the points of anchorage expansion joints are used.

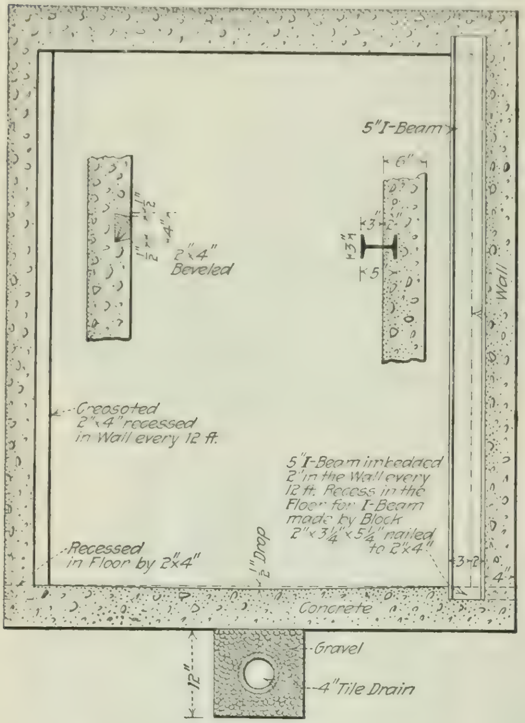

5" I-Beam
6"
3"
5"
2"x4" Beveled
Wall
Creosoted 2"x4" recessed in Wall every 12 ft.
5" I-Beam imbedded 2" in the Wall every 12 ft. Recess in the Floor for I-Beam made by Block 2"x3¼"x5¼" nailed to 2"x4"
Recessed in Floor by 2"x4"
½" Drop
3-2
4"
Concrete
Gravel
4" Tile Drain
12"

FIG. 5. CROSS-SECTION OF MAIN TUNNEL

On the opposite side of the main tunnels vertical wooden posts, made of 2 x 4-in. stock with two edges beveled ½ in., are set into the wall flush with the surface and on these uprights the electric wires are carried. The wooden posts were given two coats of boiled linseed oil before they were set in the concrete forms, so as to prevent them from absorbing moisture.

In the small tunnels the method of carrying the pipes is different. When the concrete walls were built, angle irons were set in across the tunnel about 3 in. below the roof. From these crosspieces the smaller sizes of pipe are suspended by common ball-and-socket hangers, allowing the pipes to swing freely in any direction except at the anchorage points.

New York Workmen's Compensation

A night engineer employed in a New York piano factory was fatally burned because of a back draft in the ignition of highly combustible refuse which he was burning in his employer's furnace; and his executors sued to recover damages on the ground that the furnace had been negligently permitted to remain in a condition rendering it dangerous as a means of disposing of refuse.

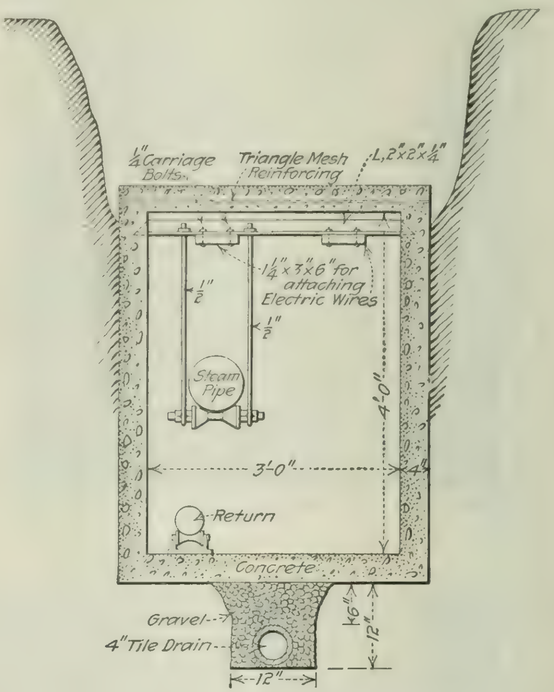


FIG. 6. CROSS-SECTION OF BRANCH TUNNEL

It is held, however, by the Appellate Division of the New York Supreme Court that the employment was one of those hazardous occupations covered by the New York Workmen's Compensation Act, and that an ordinary personal-injury suit would not lie in the absence of a showing that the employer had failed to secure payment of compensation under the Act, thereby permitting bringing of suit, as distinguished from an application for an award under the Compensation Act. (Nulle vs. Hardman, Peck & Co., 173 New York Supplement, 236.)

Because of the nature and extent of the equipment needed, the successful exploitation of oil-shale deposits involves large capital, as well as technical chemical ability.

Fuel Conservation in Massachusetts

By THOMAS HAWLEY

GREAT good has been accomplished and much coal saved for New England by the fuel-conservation plan carried out in Massachusetts. A sufficient number of practical first-class engineers were selected, and each man was assigned not over ten steam plants in his vicinity. To these plants he was expected to act in the capacity of visiting and advising engineer. His employer was asked to donate the time away from his own plant necessary for the engineer to do this work. This plan was followed in every city and town where there were more than eight steam plants, and with few exceptions every city and town was so organized. If a town had fewer than eight steam plants, those plants were inspected by field engineers sent out from headquarters in different parts of the state.

Worcester was the first city organized and had, in addition, the effective coöperation of a committee of manufacturers toward the same end. The work accomplished was noteworthy, and there is positive record of large savings in coal as a result. Fall River and Lowell were also well organized, and very satisfactory results were obtained. Cambridge and Somerville, were inspected 100 per cent. under the chairmanship of A. H. Eldredge, M. E., with most gratifying results, and in the smaller places the work was equally effective.

The visiting engineers in each locality were organized into a committee for that town and suggested changes of practice or equipment were made after this full committee had debated and agreed upon what should be done. All recommendations of visiting engineers had therefore to be approved by the full committee. These men not only inspected steam plants, but made recommendations in an advisory capacity, and their attitude was always to be that of coöperating with the management toward more economical generation and use of power. Each of the plants assigned to a visiting engineer was to be visited by him at different times during the winter to report upon what changes had been made and the economies effected and what plans were on foot for further saving.

Classification of Plants That Were Inspected

At the time of the armistice some of the engineers had made several visits to every plant under their charge. In Boston forty engineers were drafted for this work, divided into three committees, each committee meeting once a week, and it is probable that the work of conservation will continue in many plants even though the organization has been discontinued. The plants inspected were divided into three classes. In class A were plants which were apparently well equipped, in the fact that they were in good physical condition, having feed-water heaters, all exhaust steam used, heating returns saved, traps in good condition, pipes well covered and settings in good condition. Class B included plants in which some changes were suggested, but not very extensive. Class C comprised plants in poor condition, without proper equipment.

Of 250 power plants (not including large electric or refrigerating plants of the city institutions of Boston) that had been fully inspected in Boston up to the time of the armistice, 120, or 55 per cent., were in Class A, and 50, or 23 per cent., in Class B; 45, or 22 per cent., were in Class C or had not been classified. Only two of the Class C plants used over five tons of coal a day, so that the whole tonnage of the poor plants was very small. This showing indicates that 78 per cent. of the plants of Boston were in such physical condition that skilled engineers could find very little to suggest in the way of new equipment. This figure will also fairly represent the condition of the plants in the neighboring cities and towns. And yet nearly all these plants had reported savings in coal ranging from 5 to 45 per cent. in comparison with similar months in previous years, and if the work had been kept up, a still greater saving would have been shown. This saving came by the constant watchfulness on the part of the operating force and stoppage of the little leaks that so steadily make up large losses.

Response of Owners to Suggested Changes

Of all these plants, only two used the CO_2 machine, and neither the engineers nor the owners took kindly to the suggestion that such a machine might be profitably employed. No report was received that any owner installed one at the suggestion of the visiting engineers, although every suggestion was, with rare exceptions, well received and fully considered.

Few plants were reported as using the draft gage connected over the fire, but the installation of this device was recommended in many cases as an aid to better conditions, particularly where heavy or exceptionally thin fires were observed, and many plants have installed them, deriving much satisfaction from their use. The proper draft over the fire was sometimes determined by the CO_2 machine, but commonly set at about 0.3 in. In many of these places the fireman no longer watches the steam gage, but watches the draft gage instead, and if it starts to go down he immediately knows his fires are getting thin and places a small amount of coal on the fire in such a way as will bring the draft gage back to proper position again. Unconsciously, these men have thus become accustomed to firing light and often with marked improvement in economy. If the inspection work had continued, many of these instruments would now be in use with a considerable change in the practice of firing.

Another interesting fact observed was that a great majority of moderate-sized plants in this vicinity are operated at a rate of combustion of 6 or 7 lb. per square foot of grate per hour. There is a very strong opinion among firemen and engineers that this is about right, while it was the recommendation of the majority of the visiting engineers that this rate should be increased. This could be done in some cases by cutting out a boiler, and in others by cutting down the area of grate surface. This proved not so easy a task because the firemen, firing the same as before, would lose steam pressure, and had really to be educated to firing under the new conditions. But when they later became accustomed to the change, they had no difficulty in keeping up steam with less fuel expenditure. In one case reported, the area of grate was gradually cut down from 36 sq.ft. to 18 sq.ft. with a marked increase in economy. There is opportunity here for considerable missionary work among engineers and firemen, and visiting engineers were considering how best to handle that problem at the time the work ceased with the end of hostilities.

Condition of Boiler Settings and Baffles

Another important saving was effected by covering boiler settings with plastic, even settings that showed no positive indication of air leaks. In all these cases the visiting engineers reported that increased economy had been obtained. Little or no attention appears to have been paid to obtaining positive knowledge concerning the condition of the flame baffles in water-tube boilers. The great majority of engineers have never made any tests in this particular, nor made any special effort to keep the baffles tight. It was the opinion of the visiting engineers that much could be saved if the baffles were repaired at regular intervals, and this was one of the matters slated for later discussion. Where piping was found uncovered, the saving to be obtained by covering appeared to be quite clear, although there was considerable objection to the suggestion that feed-water pipes should be covered between heater and boiler, even on the part of the engineers operating the plants.

Very few plants were found that kept any intelligent records of the work they were doing. Some plants—not over 15 per cent.—had feed-water thermometers, but few had any means of weighing coal or measuring water, and suggestions that apparatus for these purposes be purchased were not well received by the owners. The attitude adopted by most owners was one of coöperation during the war, as a war measure, wherever a saving could be clearly shown, as in the case of a more efficient feed-water heater, covering steam pipes, using exhaust steam, saving waste returns, etc. But any refinements or helps that might make the work of the operating force easier and more sure of better operation were not so readily considered, although owners were anxious enough that the men should be economical with such apparatus as they then had.

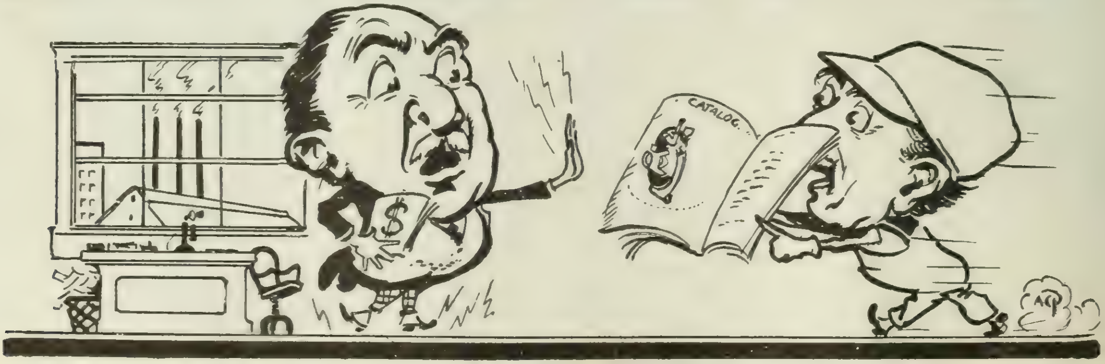
There seems to be no doubt that much coal has been saved in Massachusetts, but it has been done by the earnest coöperation of the operating force in the power plant and the factory force, and not by changes that cost the owners money. The opportunities for even greater saving exist, and it will be regrettable if this does not continue. The owners of steam plants should not expect their operating force to accomplish this without some assistance or at least recognition of its accomplishment.

Here is one case that was reported: After wrangling and protesting against the indifference of the superintendent, an engineer made some changes that he believed would improve economy. The coal bill for November had fallen from 111 tons in 1917 to 65 tons in 1918. This could be accounted for by the comparative mildness of last November, but the engineer insisted that the heating was completely by exhaust steam and not all of that was used, so the saving did not come there. This saving, at the price of coal in Boston, nets the owner over $400 per month, and yet the engineer was not even thanked. He now has a plan to make a further saving of about $100 per month by some other small changes, but he has met the same violent opposition as before and is treated with scant courtesy. What is that engineer to do? His professional pride compels him to insist on those changes, but his employers' attitude encourages him to let the matter drop, and as the war stimulus is no longer upon him, that is what he will doubtless do.

Conclusions Drawn from Plant Inspections

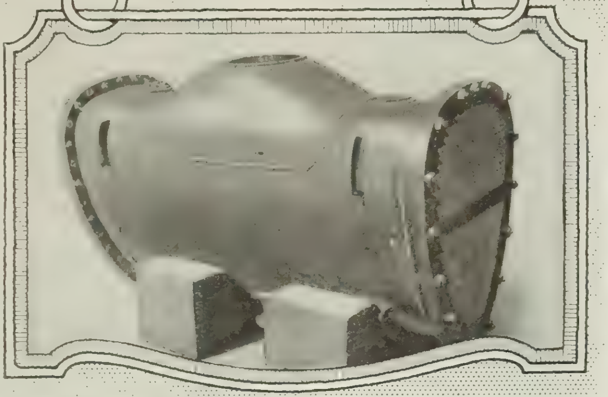
Inspections have shown that many plants apparently well outfitted could be rearranged with great improvement in economy. They have shown no attempt whatever to furnish plants with recording instruments or to keep proper operating records. They have shown that large economies can be effected whenever the operating force concentrates its energies to that end. They have shown that no effort has been made by the owners to secure the best from their employees, but rather a disposition to hamper an engineer whenever he makes a suggestion that may involve expenditure.

More than ever it has become apparent that great savings can be effected through the constant efforts of the operating men, but it cannot be done until good performance in the power plant is rewarded, for then the operating men have an incentive to save. Since inspections ceased there have been many evidences that the work of conservation will go on, for a time at least. The operating forces in Massachusetts are more intelligent than ever before and have shown what they can do. If those for whom the savings are made will now coöperate, the operating forces will respond.



Some Examples of Electric Welding

By J. O. Smith



ELECTRICITY as a means of welding in repairing cracks or breaks in metals, salvaging defective castings and for cutting purposes, all included under the general head of electric welding, is being used to a greater extent than ever before. Although comparatively simple in theory, the development of the use of electricity in this form has been slower than in any other service in which it has been applied. This slow growth is probably due to two causes—the scarcity of skilled operators and apparatus suitable for performing the actual operation.

During the last two years, however, arc welding has made great strides, and undoubtedly a great stepping stone, by means of which it has attained greater prominence and the confidence of engineers in general, was through the successful welding of the damaged parts of the interned German ships at New York at the outbreak of war in the spring of 1917. The work done on the engines of the damaged German ships demonstrated to the engineering world in general that electric welding could be depended upon to make lasting repairs, no matter how large the part to be welded or the character of the metal. In these ship repairs, made by the Wilson Plastic-arc system, the intense heat of the arc was used to bring the metal to a melting or fusing point. This arc is convertible, which permits of its application to any desired point.

The arc itself is produced between the material to be worked, which is connected to the positive side of the circuit, and a rod, usually of the same material, which is connected to the negative side. This electrode of welding metal is so proportioned that the amount of the elements burnt out by the arc is compensated for. Thus the chemical resultant in the weld is predetermined.

The system under discussion employs a standard flat compound 35-volt generator to feed a special constant-current controller. The carbon pile and a solenoid that operate the arc, are in series with it, so that the current through the arc is controlled by the automatic variation of the resistance of the carbon pile in response to the pull of the solenoid. The pull of the solenoid is balanced in turn by a spring connecting from a leverage, and the current adjustment is made by changing the leverage. The pilot motor, which may be controlled by a switch from the welding-tool handle, regulates the leverage so that the operator can change the current at the arc, if necessary, without leaving his work or extinguishing the arc. Fig. 11 shows a two-arc 300-ampere welder. A few applications of the work accomplished by electric welding in boiler and other industrial work are shown in the illustrations. That welding can be done in confined spaces is shown in Fig. 1, where boiler tubes are being welded to the tube sheet of a locomotive type boiler. In Fig. 2 are shown repairs by arc welding to a boiler, some of the rivets of which have failed, resulting in a leaky seam.

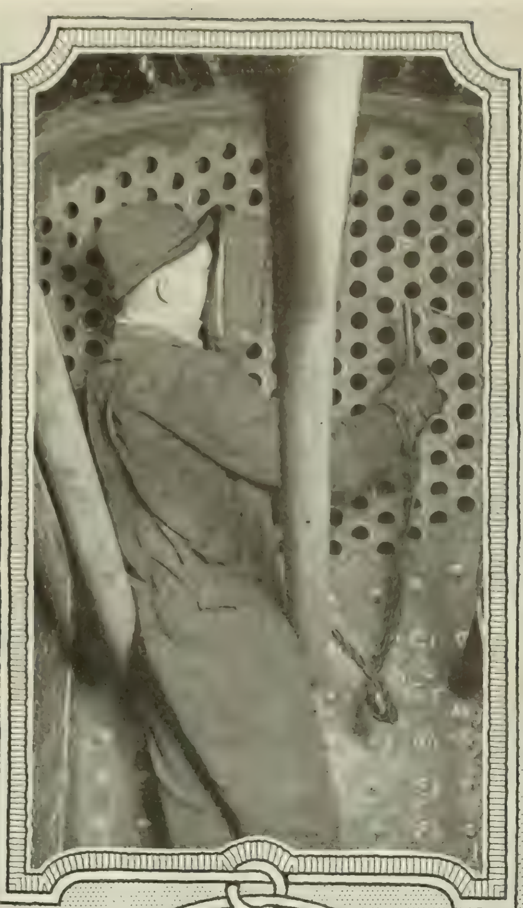
Another example of welding, where the service is severe, is illustrated in Figs. 3 and 4, which show before and after welding views of the repair of a locomotive frame. The frame was broken at *B*, and in cutting out the defective part a large space was left between the two ends of the frame. The filler *B* is a new piece of metal set in and tacked with the welder and is ready for the completion of the job, which is shown in Fig. 4. The work required 41 lb. of electrodes, 125 to 150 amperes at from 35 to 40 volts. The welding time for one welder was 30 hours, using in that time approximately 165 kilowatts of electric energy.

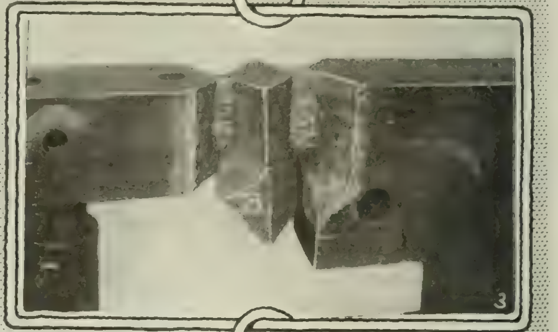
Figs. 5 and 8 are examples of riveted seams on a large oil tank that have opened and are being welded tight, three welders working on the job at the same time, Fig. 8. A close-up view of the welding shown in Fig. 5, illustrates the method employed in depositing metal along the leaky seam.

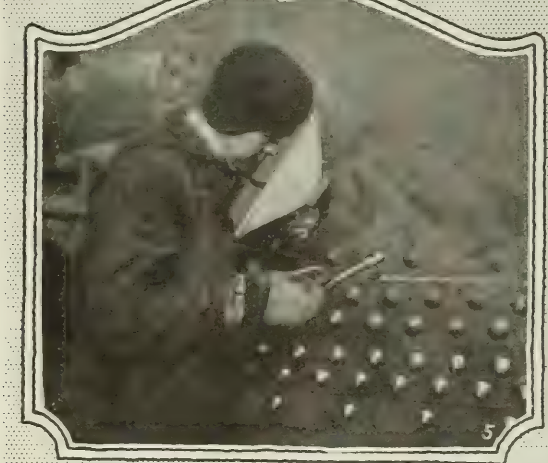
That electrical welding is suitable for commercial work is shown in Fig. 6, where there are illustrated a number of welded joints of $\frac{5}{16}$-in. plate used for ventilator pipes.

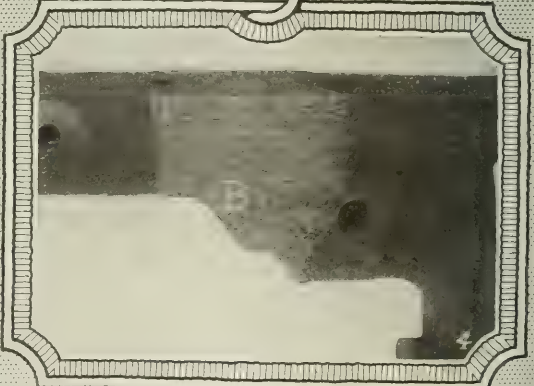
The adaptability of this method of welding for light work is again shown in Fig. 7, which is a sheet-steel fuel-oil tank welded complete without the use of rivets. This work was done by the Squantum works of the Bethlehem Shipbuilding Corporation, as was also the welding on a pressed-steel condenser shown in the headpiece illustration. This condenser is said to be the first of its kind ever welded, and this method of joining a metal condenser has been adopted as a standard method of construction by the Bethlehem Shipbuilding Corporation.

Frequently pulleys, flywheels and gears are fractured, and in most instances the damaged member is replaced by a new one, whereas they can be repaired by welding

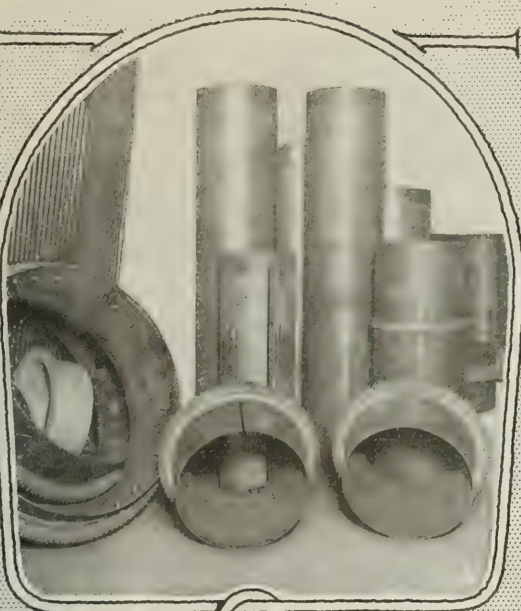


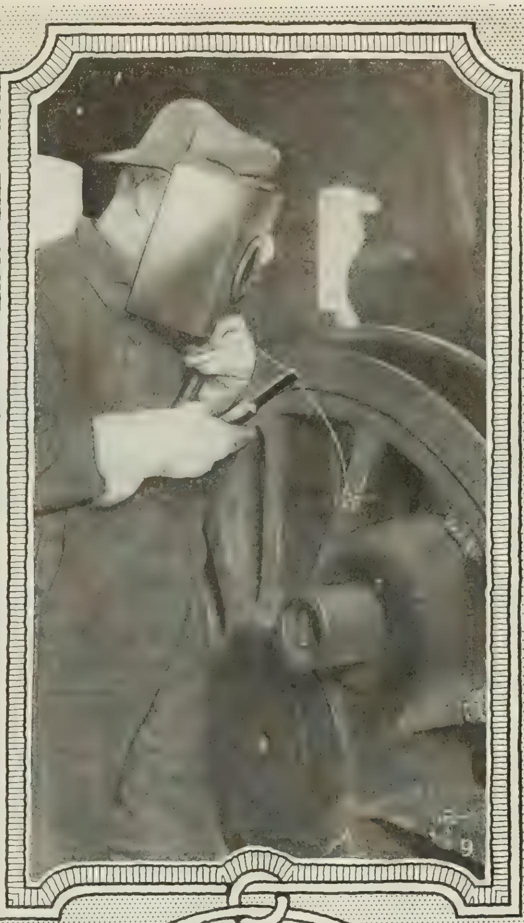


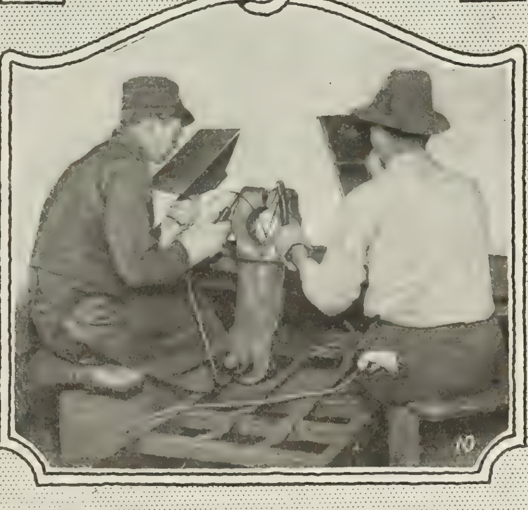


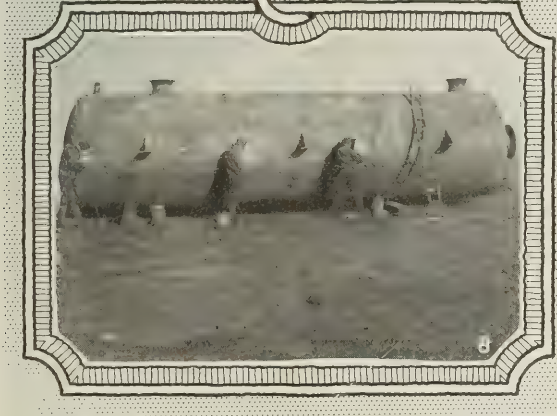


FIGS. 1 TO 5. EXAMPLES OF REPAIR WORK PERFORMED BY ELECTRIC WELDING
Fig. 1—Welding boiler tubes to boiler sheet. Fig. 2—Welding leaky riveted boiler seam. Figs. 3 and 4—Locomotive frame before and after welding. Fig. 5—Depositing metal along leaky seam.









FIGS. 6 TO 10. MORE EXAMPLES OF ELECTRIC ARC WELDING

Fig. 6—Welded ventilator piping. Fig. 7—Welded oil tank. Fig. 8—Three welders working on one job. Fig. 9—Welding locomotive driving wheel. Fig. 10—Filling in a crank arm.

as is shown in Fig. 9, which is an example of heavy repair work on a main driving wheel of a locomotive. It is evident that such a weld will be subjected to much more severe operating conditions than would be the case of pulleys, etc.

Fig. 10 establishes the fact that a great deal of time can be saved by using two welders at once on the same job. The illustration shows the filling in of a cast-steel engine crank arm preparatory to reboring.

That welding, if properly done, can be applied to boiler work was demonstrated in the case of a boiler header that was welded recently by this system. A pressure test was then applied to the boiler to determine its holding qualities. After the ordinary test pressure, a special pressure of 3500 lb. per sq.in. was applied, and not a single defect, not even a pinhole, developed. The only outward evidence of the unusual pressure being applied was the bulging of the header. No machine could be procured around Chicago that could provide a higher pressure on the boiler, and the tests were considered conclusive evidence of the holding qualities of the weld.

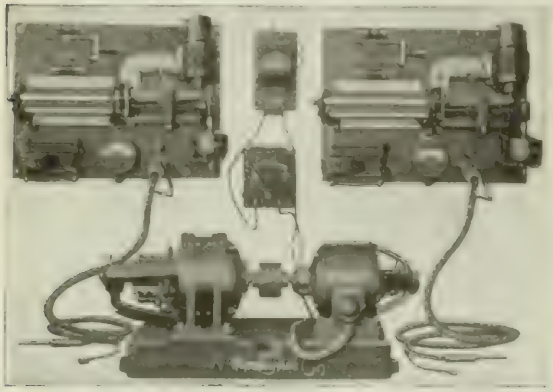


FIG. 11. TWO-ARC 300-AMPERE ELECTRIC WELDER

Tocknell Compressed-Air Vibrator

Most piston movements are controlled by a mechanism outside of the cylinder, but in the Tocknell compressed-air vibrator, Fig. 1, patented by Charles W. Tocknell, Kenilworth, N. J., the control of the piston movement is by means of valves that work in three so-called cross-walls, the movement of the cylindrical valves being controlled by the piston striking them and thus moving them from one end of their travel to the other. Each valve has a longitudinal bore extending through the greater portion of its length and two transverse ports that communicate with the longitudinal bore. Each valve is also provided with a head at both ends, and one head of each valve at opposite ends has a transverse groove connecting with the longitudinal bore of the valve.

A piston rod carries two pistons. The rod also passes through the center of the spacing collars. The piston has a longitudinal bore from one portion to the other, which connects with a transverse bore and which aligns with a similar transverse bore.

In operation, with the parts in the position shown in Fig. 2, pressure is admitted through the pipe *A* into the chamber *B*, and passes through the port *C* to the bore *D* of the valve *E*, and through the groove *F* to the space between the stationary wall, and the piston *H*. The pressure will force the piston *H* toward the right, and the piston *J* with it. The air trapped between the piston *H* and its cylinder head will pass through the port *K*, and the bore in the piston rod to the space between the piston *J* and its cylinder head.

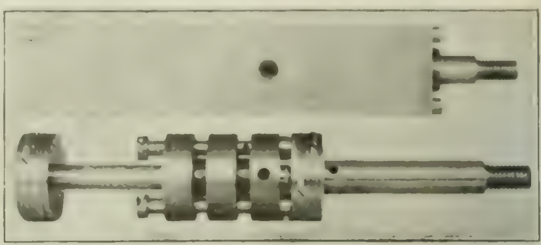


FIG. 1. CASING, PISTON AND VALVES OF VIBRATOR

When the pistons have traveled a distance sufficient to bring them to the position shown in Fig. 3, the piston *J* comes in contact with the heads of the valves and forces them to the position shown. This brings the port *C* within the wall *D* and closes this port. This movement of the valve also brings the port *L*, which has been closed within the wall *M*, into the chamber *B*, Fig. 2, when the pressure will pass through the port *L*, Fig. 3, the bore *N* and the groove *O* to the space between the piston and the cross-wall *P*. This will force the piston *J* toward its cylinder head. At the same time the pressure that has been accumulating between the piston *H* and the cross-wall *D*, Fig. 3, is free to escape through the bore *R* of the top valve and the port *C*, which, in the new position of the valve, is situated in the chamber *S*, Fig. 2, thus permitting its discharge to the exhaust pipe. The cycle of events then follows as long as pressure is admitted to the cylinder.

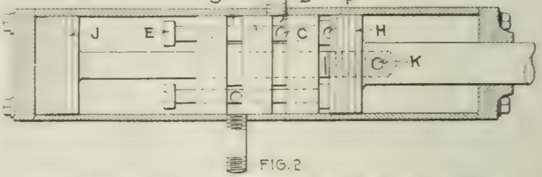
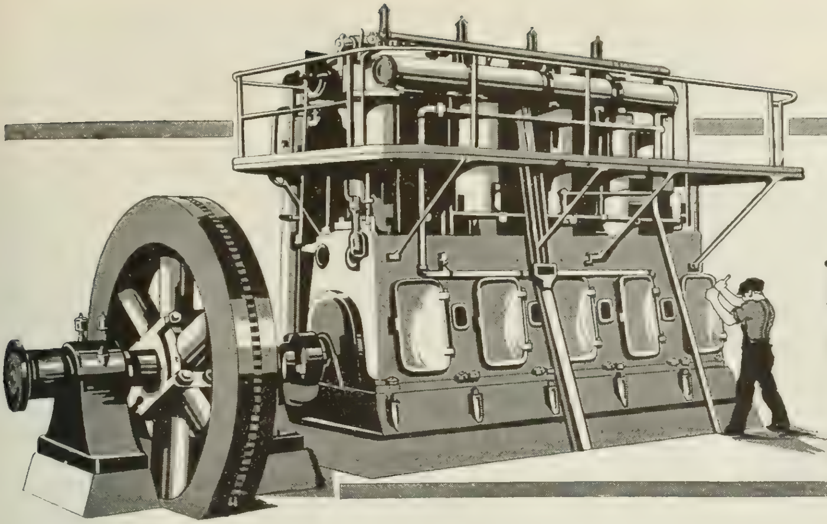


FIG. 3

FIG. 2

FIGS. 2 AND 3. SECTIONAL VIEWS THROUGH AIR VIBRATOR

There is no necessity for screwing any kind of packing up tight. If the rod is in good condition the packing can be made tight enough by merely screwing up the gland nuts with the fingers while the packing is cold. The application of steam to the cylinder and around the rod will cause the packing to become steam-tight.



Talks on DIESEL Engines

by L. H. Morrison

X—The class learns how to determine when a valve needs regrinding, how to perform that operation and how to time the action of the inlet and exhaust valves.

"LET'S see—I promised Sandy I'd take up valve grinding tonight, didn't I?" Egan announced.

"Yes—and Sandy's not the only one that wants to hear about it," said Woods. "Seems to me I've seen more about that than about any other subject connected with Diesel engines."

"Well," remarked the chief, "in my opinion it's worth discussing. A lot of good engines have been damned because the engineers didn't know how to grind the valves."

He spread out a sheet showing a sketch like that in **Fig. 1**, before he continued his story.

"I've noticed that many engineers will remove the dash-pot and spring and grind by giving the valve a continuous rotating motion. The proper way is to remove the spring and insert a light spring *A*, as I show here. Leave the dashpot *B* in place to act as a guide in keeping the valve stem central. The idea of the light spring is to lift the valve off its seat when the pressure is removed. Put a light coat of extra-fine emery paste on the seat, press the valve down until the two surfaces to be ground are in contact, and rotate a half-turn back and forth, letting the valve rise off the seat at frequent intervals. Apply more paste and rotate over the other half of the cage seat. This will grind the whole. The idea of allowing the valve to lift occasionally is to prevent the seat from being ground convex. If this is not done, the edges only will be ground. As to the width of the ground part of the seat, a sixteenth of an inch is ample. I always like to see this much ground so that it will reflect light, like a mirror."

"I don't see how you are going to grind that good, when every time an engine is shut down there is always a rush to get it back into service quickly," Woods argued.

"It's always desirable to get an engine back into running order as soon as possible and on this account I'm afraid some of our valve grinding has been more on a 'lick and a promise' order. This is because we have no extra cages. I have asked for two extra cages and valves, and, when they arrive we will arrange to keep the spare ones ground and ready. This will allow us to use plenty of effort on our grinding. Over at the Clarksburg plant they grind the set just as soon as it has been removed from the engine; then the cage and valve are coated with lubricating grease to keep the bright surfaces from rusting."

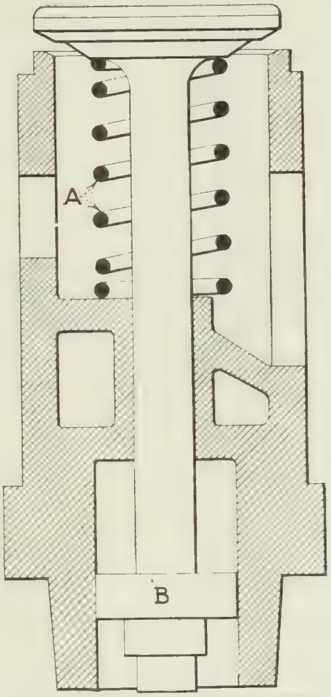


FIG. 1. USE OF LIFTING SPRING IN GRINDING VALVE

"J. R.," Kelly spoke up, "you tell us how to grind valves; but what gets me is—how am I to tell when a valve needs grinding without taking it out to see?"

"Well, Kelly, there are certain indications that should govern you in this matter. Beginning on the inlet or admission valve, a leak can usually be detected by placing your ear to the admission nipple. If there is a worn or scored

Next week Egan will take up the construction and action of fuel valves of various forms and he will point out how to care for such valves

inlet valve seat you'll hear a whistling sound that will grow louder as the leak grows larger. If you neglect it, the leak will get so bad that you will lose your compression. If the cam is not timed correctly and the valve fails to seat at the proper time, the air will blow back through the admission opening with considerable force.

"Now you see that is simple. But when you come to the exhaust valve, a leak is harder to locate. If you feel suspicious, stop the engine and bar it over until it is in the position where both the inlet and exhaust valves should be closed. Then crack your air valve, and, if the valve leaks, the air will blow out through the exhaust pipe. In order to make certain, the exhaust pipe should be tapped for a ¾-in. cock close to the exhaust opening. Do you get that?"

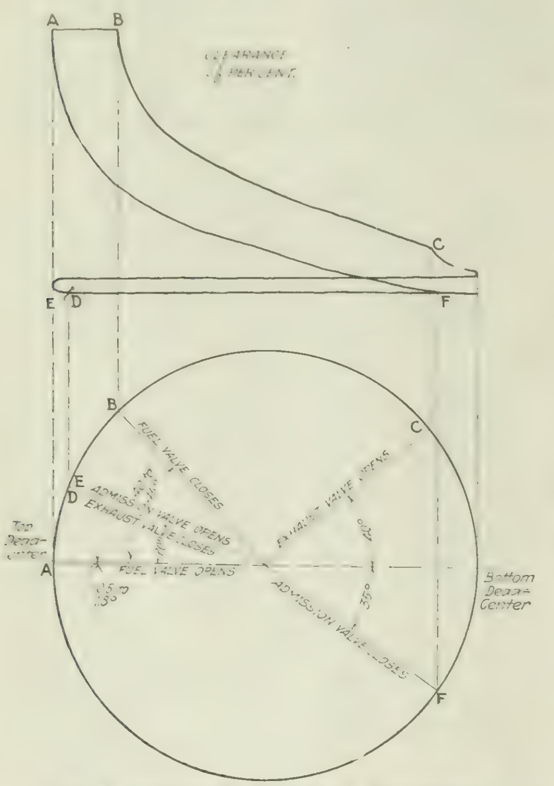


FIG. 2. TIMING OF VALVES AS SUGGESTED

Kelly nodded, and Egan resumed the discussion with renewed earnestness.

"In my opinion the thing that requires the closest attention is the proper clearance between the valve rocker arm and the cam. Of course, this will vary a little in different engines. In the absence of definite instructions from the builder, a safe value is from 0.02 to 0.04 in. This will take care of any expansion of the valve stem due to heat and at the same time is small enough that no hammer blow is delivered by the cam as it strikes the rocker roller."

"How about timing the valves?" Kelly asked.

"In the setting of the points of opening and closure of the valves you will find considerable differences in the values suggested by different builders. One company gives no data on its engines beyond the original setting at the time of erection. In such cases all an engineer can do is to check the values and make a note of them so that in the future the valves can be kept to the original settings.

"It's of little use to take values given in technical articles. These usually are the values that are correct from a theoretical standpoint and take no account of the fact that the valves do not open and close instantaneously. Recently, I ran across a volume on Diesel engines that contained a lot of valuable information, but when the author began to talk of valve timing, he lost his bearings. For example, here are the settings he recommends: Fuel valve opens 0.5 to 1.8 deg. before top dead-center and closes 40 to 45 deg. after top dead-center; exhaust valve opens 40 deg. before bottom dead-center and closes 20 deg. after top dead-center; admission valve opens 20 deg. after top dead-center and closes 35 deg. after bottom dead-center.

"'Compare these values with the settings we use on the three makes of engines we have here: Fuel valve opens 7 deg. before top dead-center and closes 28 deg. after top dead-center; exhaust valve opens 50 deg. before bottom dead-center and closes 20 deg. after top dead-center; admission valve opens 20 deg. before top dead-center and closes 35 deg. after bottom dead-center. The diagrams shown in Figs. 2 and 3 are based on the foregoing theoretical and practical values, respectively. You can see the difference very plainly.

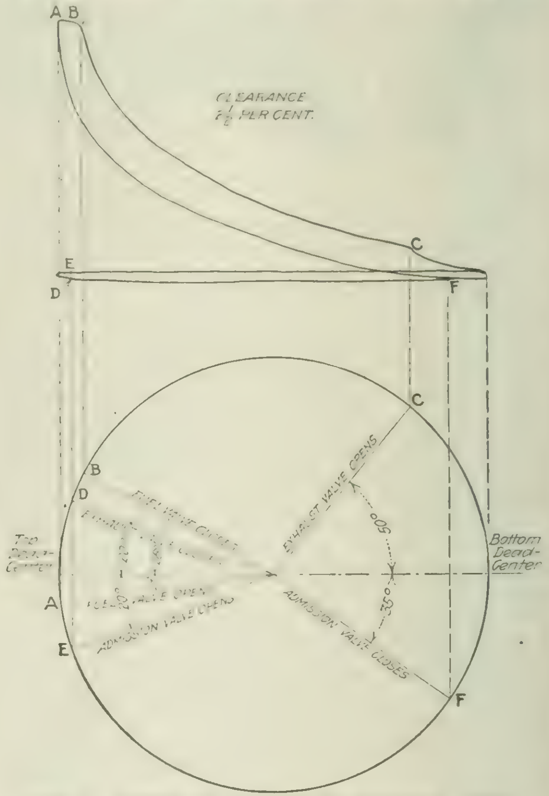


FIG. 3. TIMING OF VALVES AS ACTUALLY USED

"The valve settings used on the Busch-Sulzer engine are given in the table. All the values are in inches, and are measured on the flywheel, on the circumference of a circle 108 in. in diameter. If you convert them into degrees, you'll find they agree pretty well with those I've just given for our engines."

"But, chief," Woods ventured, "why do you say that theory and practice don't agree? I am not well up on that stuff, but I always thought theory and practice had to agree."

"Maybe I did speak hastily," Egan confessed. "What I should have said is that the theoretical and the practical values are different because they are based on different conditions. Take the theoretical values, for instance. You see the fuel valve opens 1.8 deg. ahead of top dead-center while in practice we have it open 7 deg. ahead. This late opening is based, I presume, on the use of a light oil that will atomize and burn instantaneously on entering the cylinder. In this case it is not necessary to open the fuel valve early. In our case we use a fairly heavy oil that doesn't atomize easily, and so it's necessary to open the fuel valve early.

"The theoretical point of fuel-valve closure is too late and all the fuel would not be burned in the cylinder. This is based on the assumption that the fuel charge is being injected into the cylinder during the entire time the fuel valve is open. Actually, the fuel charge has been atomized long before the valve closes, and all that enters through the fuel valve during the latter part of its opening is highly compressed air. This air would tend to increase the pressure in the cylinder, and the indicator card would show an increased indicated horsepower. But it takes power to compress this excess air used, and as a result the net brake horsepower is decreased with lengthening the period of fuel-valve opening beyond what is actually required.

VALVE SETTINGS USED ON BUSCH-SULZER DIESEL ENGINE OF 500 HP., AT 200 R.P.M.

	Number of Cylinder			
	1	2	3	4
Fuel valve opens before top center.........	7⅝-9	8¼-8¾	8-8¼	8½-8
Fuel valve closes after top center	28½-16	30-17½	30-17½	31¼-18½
Clearance between roller and cam . .	0.004	0.004	0.004	0.004
Starting valve opens after top center.......	......	4	4	
Starting valve closes after top center.......	......	60¾	61	....
Clearance between roller and cam. . .		0.012	0.012	.
Admission valve opens before top center....	22	24½	22¼	23¼
Admission valve closes after bottom center.	37½	41	40½	41
Clearance between roller and cam.........	0.012	0.012	0.012	0.012
Exhaust valve opens before bottom center..	61¼	61¼	61	60¼
Exhaust valve closes after top center.......	21½	20½	20¼	22¼
Clearance between roller and cam.........	0.02	0.02	0.02	0.02
Delivery of fuel pump (governor in central position)....	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{7}{16}$

"Turning to the admission-valve operation, the theoretical table recommends that the valve open 20 deg. after top dead-center, while we usually have it open 20 deg. before top dead-center. If the valve delays opening until the piston starts to return on its suction stroke, surely part of the burnt gases in the exhaust piping will be drawn back into the cylinder. Then the pure-air capacity of the cylinder will be reduced 20 per cent. This will also show up in the indicator card by causing the suction line to drop farther below the atmospheric line than it does when using our setting. Of course, this decreases the horsepower."

"Chief," Woods broke in, "is it a good thing to have the exhaust valve open so early? From what I can learn of steam engines, early release is bad."

"It would be very desirable to have the expansion line continue until the pressure in the cylinder equaled the atmospheric pressure, but this would cause too large a cylinder for the horsepower developed, thus making first cost excessive. I will admit that it would be practical to have the release occur later than is customary. This cannot be obtained as long as the builders make the exhaust valve so small. As it is, it is necessary to open early in order to free the cylinder of excessive back pressure."

Egan consulted his watch, and then pushed back his chair. "Well, boys, it's bedtime. When we get to fuel valves, we can discuss any other ideas about valve setting that may occur to you."

Refrigerating Installations in 1918

The record for the year 1918, as compared with 1917, shows a considerable decrease in the number of installations, and the total regrigerating capacity, according to *Ice and Refrigeration*. Reference to the table herewith shows that 979 installations, with a refrigerating capacity of 24,621 tons, were made during 1918, as compared to 1656 installations with a capacity of 39,738 tons for the year previous. The greatest decline is under the head of ice making. This, however, is largely accounted for by the Government embargo placed upon all building operations with the exception of those considered absolutely requisite; the high cost of all materials has also delayed construction.

The large installations made during the year were mainly in connection with the various camps, cantonments and naval establishments. The Du Pont Powder Co., of Wilmington, Del., added to its buildings what is reputed to be the largest refrigerating plant ever installed in a munition works, the total capacity being 3250 tons. The necessity of refrigeration in chemical manufactures, many of which were devoted almost entirely to war work, is evidenced by the number of installations made in such plants.

The certainty of adoption by the country of the prohibition amendment to the constitution is doubtless the explanation of the decline under the head of breweries.

Under the classification of miscellaneous are a number of installations in gas plants, engineering works, church buildings, state institutions, commissaries and others. That the value of refrigeration on ship board is recognized will be noted by the total of 31 vessels equipped with refrigerating machines. The United Fruit Co. of New Jersey installed plants on quite a number of its boats.

LIST OF NEW INSTALLATIONS IN 1917 AND 1918

	1918		1917	
	Installations	Tons Refrig.	Installations	Tons Refrig.
Apartment houses			3	14
Bakeries.........................	20	193	22	317
Breweries	10	415	15	1,057
Chemical works.	27	1,630	20	811
Clubs ...	14	122	7	25
Cold-storage warehouses	68	3,067	74	3,379
Confectioners	32	446	38	367
Creameries, dairies and condenseries	115	1,488	250	3,006
Department stores	8	33	4	36
Fish dealers	10	67	7	118
Grocers and general stores.......	22	119	49	184
Hospitals	43	265	49	288
Hotels	27	397	48	645
Ice cream	61	1,544	118	2,382
Ice making	89	3,383	264	16,404
Meat markets... .	97	625	234	956
Munitions .	4	6,450		..
Office buildings	19	95	10	94
Packing house	34	1,563	73	5,411
Produce merchants	23	305	48	428
Provisions and meat storage	52	221	33	436
Railroad depots	5	211	2	56
Residences	11	20	13	26
Restaurants	32	88	34	125
Schools and colleges	7	26	15	71
Shipping .	31	185		
Miscellaneous	118	1,663	226	3,102
Total	979	24,621	1,656	24,621

How Interpoles Affect the Operation of Direct-Current Machines

By R. L. WITHAM

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The influence of interpoles on the voltage of generators, the speed of motors and how the effects of the interpoles may be adjusted to obtain the best results are considered.

FROM the article, "Effect of Interpoles on Commutation of Direct-Current Machines," in the Mar. 4 issue, it may be inferred that improvement of commutation is the primary reason for the use of commutating poles, and this is quite true, but it is by no means the only way in which the operation of the machine is affected by their use. Interpoles have an influence on the voltage characteristics of generators and the speed characteristics of motors as well as on the efficiency, weight and cost of the machine. In a generator without interpoles the brushes have to be advanced in the direction of rotation to secure the best commutation at full load, but in the interpole generator they should be kept in the neutral position regardless of the load. This neutral position should be determined before the generator leaves the manufacturer, and the construction of the machine should be such that it is difficult to set the brushes in any other position. If, from any cause, the brushes should get off the neutral position, the effect upon the operation of the machine is much more marked if the machine has interpoles than if it has not. Just what this effect is can be shown as follows:

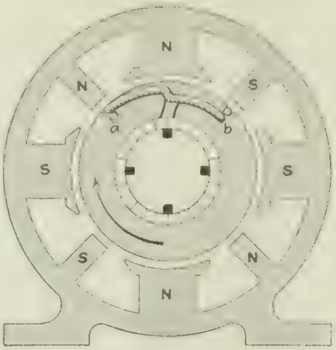


FIG. 1

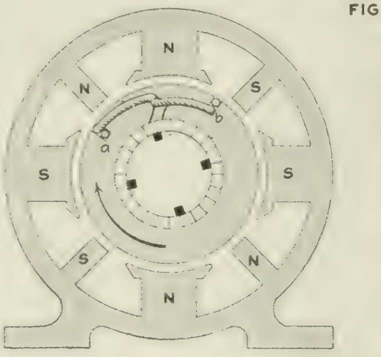


FIG. 2

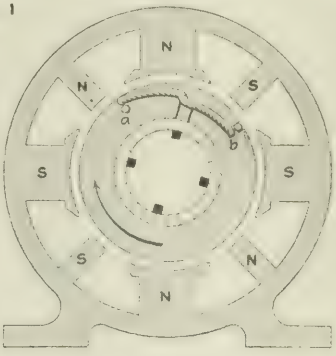


FIG. 3

FIGS. 1 TO 3. SHOWING CORRECT POLARITY OF INTERPOLES AND MAIN POLES FOR A DIRECT-CURRENT GENERATOR

Fig. 1 represents a machine with brushes in the neutral position as is indicated by the short-circuited coil being so located that each of its sides is exactly under the middle of an interpole. If the machine is a generator and the armature rotates in a clockwise direction, the polarity of the interpoles will be as marked in the figure. Now all the conductors on the armature between the points *a* and *b* are cutting the flux from the main pole *N*. If they cut any of the flux from the interpole *N*, they also cut an equal amount of flux from the interpole *S* and these two effects neutralize each other, making the total flux cut, and hence the generated voltage, independent of the strength of interpole winding.

If the brushes of the generator are given a backward lead, placing the short-circuited coil in some such position as shown in Fig. 2, the conductors between *a* and *b* will cut not only all the flux from main pole *N*, but also that from interpole *N* without including any of the opposing flux from interpole *S*. Hence it will be seen that the total flux cut is greater than in Fig. 1 and the voltage generated will consequently be greater. The greater the load on the machine, the greater will be the interpole current and the resulting interpole flux and hence the greater the total flux and the generated voltage. Thus it may be stated that shifting the brushes of an interpole generator backward tends to give the machine a rising voltage characteristic. If the generator is to operate in parallel with other machines, such a characteristic is an objectionable quality. If, now, instead of being shifted backward, the brushes are advanced in the direction of rotation so that the short-circuited coil is thrown into some such position as shown in Fig. 3, it will be seen that the conductors between *a* and *b* cut all the flux from main pole *N* and also that from interpole *S*, and since the effect of the latter is to neutralize a part of the former, the resultant flux cut becomes less the greater the load and the effect of the interpole in this case will be a tendency to give the generator a drooping voltage characteristic. Thus it may be stated that the effect of the interpole of a generator, unless the brushes are exactly in the neutral position, is like that of a series-field winding; a cumulatively connected series if the brushes are moved backward and a differentially connected series if they are shifted forward.

If the machine represented in Figs. 1, 2 and 3 is a motor instead of a generator, its speed will be affected by brush position in a manner similar to that in which the voltage of a generator is affected. In order that the relative polarity of interpoles and main poles, as indicated in Figs. 1, 2 and 3, may be correct for the case of a motor, the direction of armature rotation must be taken as counterclockwise instead of clockwise as given in Figs. 4, 5 and 6 respectively. Then Fig. 5 represents a motor with brushes given a forward lead and Fig. 6 a motor whose brushes have a backward lead. With a forward lead, as in Fig. 5, the flux cut by the conductors between *a* and *b* is greater than it is when the brushes are on neutral, Fig. 4, hence the speed of armature rotation is less. The greater the load on the motor the greater will be the interpole current and consequently the greater the interpole flux, making the speed decrease with an increase of load. Thus the forward lead of the brushes tends to give the motor a drooping speed characteristic. By a similar line of reasoning it will be seen that shifting the brushes backward, as in Fig. 6, will reduce the flux cut by the armature conductors and will tend to give the motor a rising speed characteristic.

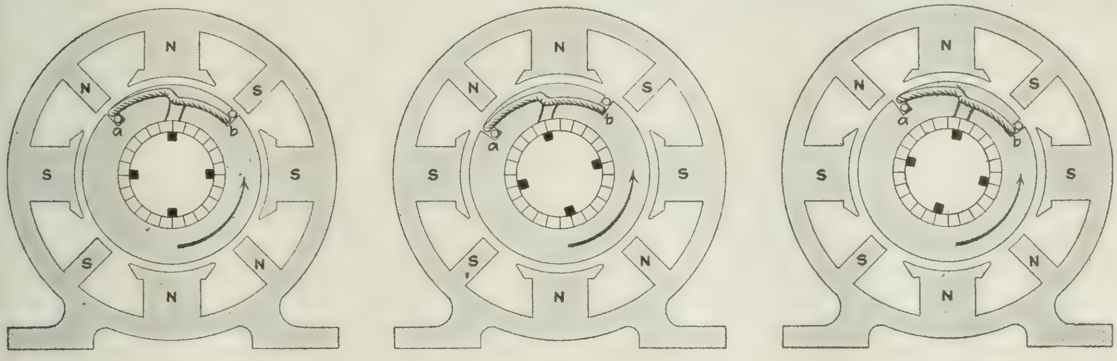


FIG. 4 FIG. 5 FIG. 6

FIGS. 4 TO 6. SHOWING CORRECT POLARITY OF INTERPOLES AND MAIN POLES FOR A MOTOR

If the interpole field of a motor is too strong or too weak, this condition will also affect the speed of a machine for the reason that the armature coils which are short-circuited by the brush react upon the main field. To explain this more fully consider first that the interpole field is of exactly the correct strength. Then the time of commutation—that is, the time required for a commutator segment to travel the circumferential width of a brush—will be made up of two equal periods; namely, that in which the current is reduced from its normal value to zero, and that in which, after reversal, it is built up again to its normal value.

If the interpole field is too strong, the reducing of the current to zero will take place in less than one-half the entire time of commutation, leaving a proportionally greater time for the building up of the current after reversal. The result will be a preponderance of current in the reversed direction over that in the original direction, and this current may be several times as great as the normal full-load current carried by the same coils when not short-circuited by the brushes. As a result, all the short-circuited armature coils constitute an aggregate of ampere-turns which may reach a considerable value and which, by reason of their location and polarity, directly oppose the main field windings and so reduce the main flux. The result is an increase in speed as the load on the motor increases. This gives rise to the condition known as instability, where the overload and overspeed, each augmenting the other, increase almost instantly to a point which means self-destruction of the motor unless its fuses, circuit-breakers or other similar protective devices operate in time to cut it off from the source of power.

The obvious remedy for such a condition is to reduce the strength of interpole field. This may be accomplished in any one of three ways: (1) By removing one or more turns from the interpole winding; (2) by connecting a suitable resistance in parallel with the interpole winding to shunt out a part of the current; or (3) by increasing the interpole air gap. The first method is open to the objection that it requires the removing of the insulation from the coils and the reinsulating and impregnating after unwinding the desired number of turns. The second method is also undesirable although it is the easiest to carry out. Unless the shunt is so constructed that its resistance and inductance are proportional to the resistance and inductance of the interpole winding, the result will be that on rapidly fluctuating loads the changes in interpole current will not occur simultaneously with the changes in load current and the entire benefit of the interpoles is thereby lost. The third method is usually not difficult of accomplishment since it is customary in building motors to bolt the interpole to the frame and to place between the pole and the frame several thin sheets of iron or steel. By removing one or more of these sheets, the interpole air gap may be increased as required. The weakening of the interpole field must not be carried too far, however, or poor commutation will result therefrom.

When interpoles first came into use, they were often added to noninterpole machines without any change in design other than possibly a different shape of main-field coils in order to accommodate the interpole windings, and these machines were usually of a slightly lower efficiency than the same machines without interpoles. Improvement in commutation or a wider range of speed were the chief objects sought in their introduction, and since the interpole field losses were added to the losses already existing in the machine and the output was not increased, the efficiency was lowered to a small extent. In the modern machines, however, where each part has been designed "from the ground up" with the idea of taking every possible advantage of the use of commutating poles, such as reducing the length of air gap, the amount of field copper and the magnetic density in the armature teeth, a machine of larger output, smaller losses and consequent increased efficiency has been developed.

It follows, then, that in addition to a marked improvement in commutation over a much greater range of both load and speed than formerly, the use of commutating poles has made possible a machine which will operate at a higher efficiency and can be built with a smaller quantity of material than an old-type noninterpole machine which will do the same work. And in these times when economy of all materials is a vital necessity, the part which the modern interpole motor is playing by replacing its more bulky predecessor is by no means insignificant.

Harrington Forced-Blast Traveling Grate

ATTEMPTS by manufacturers of traveling and chain-grate types of stokers to apply forced blast thereto are in recognition of the widespread demand on the part of power-plant designers for an automatic stoker that can be forced to a point of capacity far in excess of the limits of natural draft. Certain conditions, however, must be complied with before such an application can be considered as commercially successful. These may be briefly summarized as follows:

1. The stoker must allow the fuel to remain quiet during the combustion period, in order to avoid the formation of clinkers that would cause disturbance of the fuel bed when the ash content is in a plastic condition.

2. To avoid the accumulation of refuse in the furnace and consequent fouling of the grate surface, it must be discharged as formed, so that the ash remaining on any unit section of the grate surface is that which results from the burning of a single unit of fuel.

3. There must be no air spaces that are not periodically cleaned by virtue of the automatic operation of the adjacent parts and disengagements of any clinker that may have entered the air spaces during its previous passage through the furnace.

4. Inasmuch as the fuel bed does not require the same volume or pressure of air throughout its extent, it is desirable that the stoker be divided into compartments in such a manner that the air pressure and volume in each compartment are suited to the requirements of the fuel passing over the compartment.

5. The stoker must be readily convertible to the natural-draft type during the low-load periods.

6. Parts subjected to the heat and fusing action of direct fuel contact must be readily replaceable and subjected to no mechanical stress other than its own support and the support of its portion of the fuel bed.

Bearing in mind the foregoing principles, Joseph Harrington, of the James A. Brady Foundry Co., of Chicago, has developed such a stoker, which is shown in the accompanying illustrations.

The stoker consists of cast-iron side frames, carrying the driving gear, hopper front shaft and feed gate in the usual manner. The side girders are formed of structural-steel members, built like a truss, permitting stokers 20 ft. in length to be built. Transverse members of structural steel support a series of tracks, on which run semi-steel chains, which carry and support the grate surface and take up the stress and tension of the chain. These are provided with V-rollers to insure alignment both horizontally and vertically, and

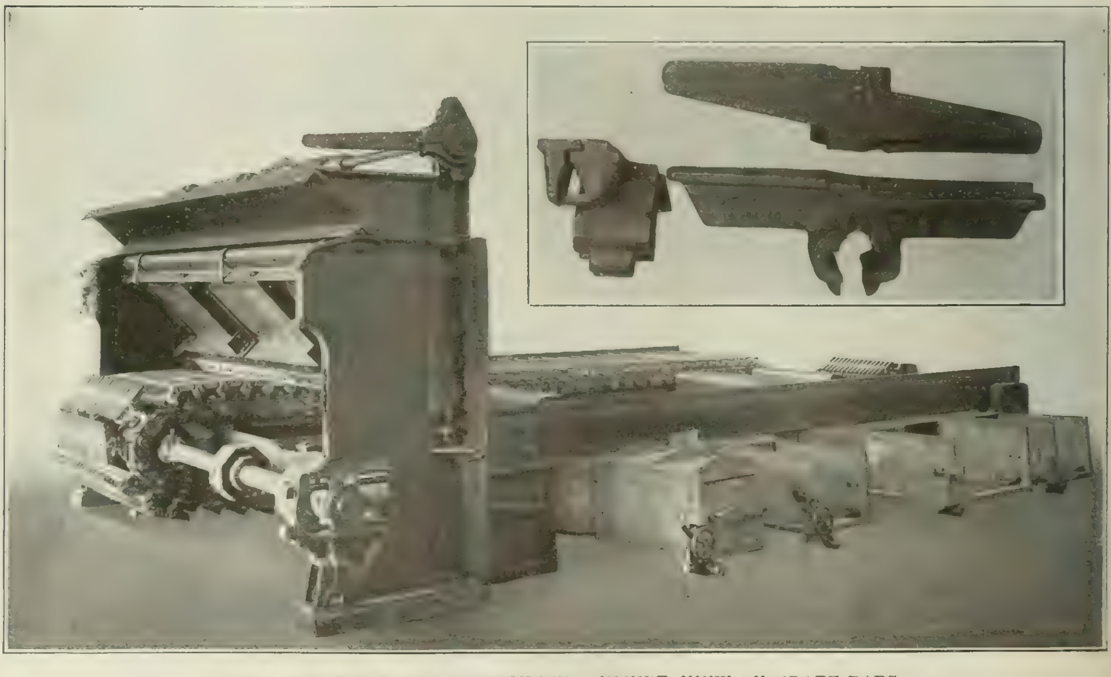


FIG. 1 STOKER PARTLY ASSEMBLED. INSERT, VIEW OF GRATE BARS

to reduce the power required for driving the stoker. An inclosed double worm drive is provided at the rear of the stoker. Attached to the chains is a series of transverse racks or beams on which the clips or bars forming the grate surface are attached.

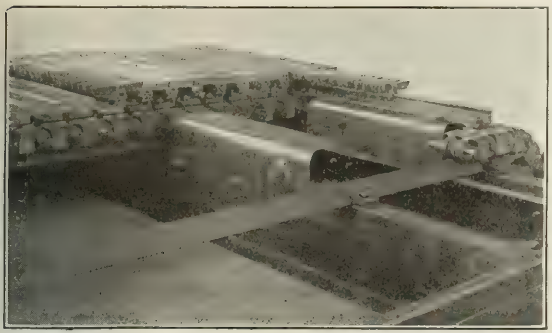


FIG. 2. SHOWING METHOD OF SEALING COMPARTMENTS

These grate bars are sufficiently loose to slide over the ends of the racks readily. The straight undersurface of these racks makes possible a practically air-tight diaphragm or seal between the adjacent compartments. These compartments occupy the space between the chains communicating on one or both sides to the air duct in the boiler side walls, or below the floor of the boiler room.

A simple form of adjustable damper serves to control the air pressure in the respective compartments. Each communicating passage through the side wall terminates in a removable door which, when taken off, allows free access to the chamber. The closing of the damper and the removal of this door serves to put the stoker on a natural-draft basis. A reversal of this process converts it to a forced-blast stoker.

One of the novel features which will appeal to engineers is the nonsifting grate surface which can be furnished with this stoker when desired. The grate bars so fit together that the air in passing through them makes two right-angle turns, and the lower shoulder at the joint prevents the falling of fuel through the grate. Projections hold the adjacent surfaces apart so that an air space of approximately 15 per cent. is insured.

Fig. 1 is a view of one of these stokers partly assembled. It was designed to burn coke breeze, but the only variation from the standard type is that the grate bars are a little closer together to provide less air space. It has four compartments, the one under the central part of the grate having double the width of any one of the others. The method of sealing the compartments and the general construction are evident in Fig. 2. Underneath the lower run of the grate an extension is built out over the ashpit to protect the bars from radiated heat, and a seal under the rear cross baffle is carried up as close as possible to the moving surface. These provisions obviate the need for a waterback or an overhang to the bridge-wall.

The chambers communicating between the compartments and the common air duct from the fan are shown in Fig. 3. The duct passes immediately below and a common plate damper in the bottom of each chamber controls the volume of air to each compartment. The dampers are operated manually by means of the lever and handwheel shown in the photograph. Each damper can be set in accordance with requirements while the total air supply is controlled through the fan serving the stoker. As previously stated, a transfer to natural draft is effected easily by closing the damper in each communicating chamber and taking off the end doors.

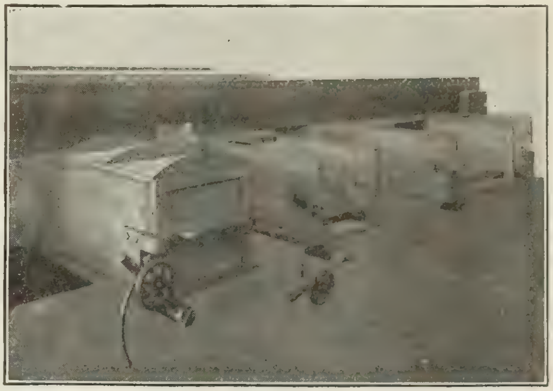


FIG. 3. AIR CHAMBERS BETWEEN COMPARTMENTS AND AIR DUCT

Coal Production in France

The average output per man per year underground in the Lens coal field of France was about 250 tons, while with us it is more nearly a thousand. The average earnings of a French miner were about $0.90 per day. The Courrières mines cover an area of about 13,000 acres, which is more or less completely underlaid by 40 seams of coal of various thicknesses. These vary from semianthracite to bituminous coal. The mining of these various seams was conducted to a depth of about 1200 ft. The shafts are all connected underground, most of them being hoisting shafts. Their total output was about 2½ million tons annually.

France had a normal coal production of about forty million tons and a consumption of about sixty million tons a year. Seventy per cent., or 28 million tons, was produced in the northern part of France forming a part of the area captured by the Germans. The mines in part of this area have been destroyed. Twenty million tons more coal was consumed than France produced, and the balance was adjusted by coal from England and Germany.

If Alsace and Lorraine go back to France, she will acquire a large active coal territory which is probably undisturbed and a large new and undeveloped territory in Lorraine which has been proved to contain workable coal; but some of it is at a depth of 4000 ft., and it is yet to be determined whether it is possible to mine coal at such a depth. In spite of this France will face a shortage amounting to thirty or forty million tons of coal for the next ten years. Outside of man power, coal will be her greatest need for the next few years, and on her ability to obtain that coal will depend her immediate future progress and recovery. Perhaps the United States can come to her aid.

The Mechanical Equipment of Industrial Buildings—II

BY CHARLES L. HUBBARD

In this installment the author considers the selection of type of prime mover, systems of power distribution and methods of heating and ventilating.

IN SELECTING a prime mover, a decision must be made between the engine and the turbine. Turbines, owing to their high speed and uniform efficiency under considerable variations in load, are particularly adapted to the driving of electric generators to which they may be directly connected. They require small foundations and take up little space as compared with reciprocating engines, especially those of slow and moderate speeds. Another advantage is their ability to use highly superheated steam, as no lubricating oil is required in the steam chambers.

The steam consumption of the turbine is, in general, about the same as that of the best reciprocating engine. Tests seem to show that for sizes below 500 hp. the turbine has proved rather more economical when compared with the single-valve high-speed engine, but that results are reversed with the four-valve compound engine of medium speed. For larger sizes, ranging from 1000 to 2000 hp., there seems to be but little difference in the economy of the two types of machines. Under certain conditions engines and turbines can be used to advantage in combination, as described later. In any case, the selection of a prime mover will depend largely on the proportion of exhaust steam that can be utilized when the entire season is taken into account. If this proportion is large, there is no object in putting in an expensive machine for the sake of steam economy, and simple high-speed engines will answer all purposes. As the amount of exhaust that may be utilized becomes less, means should be taken to reduce the steam consumption for power. The first step in this direction is the substitution of the moderate-speed four-valve engine for the high-speed single-valve type. If still greater saving in steam is desired, a reduction of 15 to 20 per cent. may be secured by the use of a compound engine when running noncondensing.

DETERMINING WHEN TO USE CONDENSER

The matter of condensing is one which should receive careful study. With a manufacturing plant, where the exhaust is used for heating purposes, there is no opportunity for using a condenser to advantage except temporarily during the nonheating season. In some cases, however, when the heating season is short and the plant is near a stream or pond where plenty of cooling water may be had for the pumping, this arrangement may prove a good investment. Under suitable conditions a reduction in steam consumption of from 25 to 30 per cent. may be realized by using a compound condensing engine in place of the simple noncondensing type.

Although turbines are frequently operated noncondensing in isolated plants, the best economy is obtained by the use of a condenser. Under these conditions a bleeder turbine may be employed. This type is especially advantageous where large volumes of steam at reduced pressure are needed for heating or manufacturing purposes. It is similar in construction to the high-pressure turbine, but is so designed that steam may be drawn from an intermediate stage after having performed work in passing through the high-pressure stages. It may be set to deliver steam into the heating system at any desired pressure within its range and operates automatically according to the volume of steam required.

LOW-PRESSURE TURBINE USING EXHAUST STEAM

An arrangement that may sometimes be used to advantage in large plants is a combination of a reciprocating engine and a low-pressure turbine, so arranged that the exhaust from the engine runs the turbine. In general, the steam economy of a simple engine and an exhaust-steam turbine together is always an improvement over that obtained by compounding and adding a condenser. The plant capacity is increased from 50 to 100 per cent. by exhausting through an exhaust turbine to a condenser from a noncondensing engine, while the increase by adding the turbine to a condensing outfit is from one and one-half to three times that which could be secured from the condenser alone. Arrangements of this kind, of course, cannot provide exhaust steam for heating and should only be considered as a substitute for the ordinary condensing plant under the conditions already noted.

New types of engines that have shown high steam economy are the uniflow, poppet-valve, and locomobile units. The first of these effects its principal saving by a reduction of the initial cylinder condensation. It operates most economically at a high initial pressure and costs approximately 30 per cent. more than a Corliss engine of the same capacity. The poppet valve is employed primarily to allow the use of superheated steam at high pressures. This engine also gives the best results when operated under a high initial pressure and costs about the same as the Corliss engine. The locomobile is a self-contained power plant, comprising boiler, superheater, reheater, compound condensing engine, condenser, soot blower, and feed-water heater. Its main advantage is its compactness, although the guaranteed fuel economy is exceptionally low.

USE OF PRODUCER-GAS AND OIL ENGINES

Producer-gas and oil engines have not been used extensively for this class of work in the United States. While power may be produced at low cost with a producer-gas plant, it requires skilled attention, and lack of this has given it a reputation, to some extent, for unreliability which has limited its use in connection with large and important manufacturing plants where a shutdown for even a short time would be a costly matter. Oil engines may be operated at a comparatively low cost, especially when located conveniently to the oil regions. They are compact and occupy less floor space than the steam engine of equal power. On the other hand, the cost of an oil-engine plant, is somewhat more than that of a steam plant, especially when there is considered the tendency to install more reserve power on account of the lack of overload capacity and also to provide against more frequent adjustments and repairs. Neither the gas engine nor the oil engine provides exhaust steam for heating purposes, so that a boiler plant must be furnished anyway, and this is an important factor in the selection of the power equipment.

Methods of Power Transmission in Manufacturing Plants

Of equal importance with power generation is its transmission to the various machines, for nothing is to be gained by installing expensive equipment for the economical generation of power and then wasting it in useless work in the form of friction. The different forms of power distribution in common use in manufacturing plants are included under the heads of mechanical and electrical transmission, each having its advantages under certain conditions. Mechanical transmission, which is the older method, has been greatly improved since the advent of electricity for this purpose, so that in certain cases power may be transmitted with equal or even higher efficiency than by the newer method. In making a selection, however, the actual conditions should be carefully studied and the system used which seems to fulfill the greatest number of requirements. Often a combination of electrical and mechanical distribution will prove more effective than either alone.

The improvements in mechanical transmission of power comprise lighter shafting running at higher speed; the substitution of wooden pulleys for iron, which not only reduces the weight but increases belt efficiency; the use of solid flanged couplings, with split pulleys and clutches so that shifting and replacements may be made without disturbing the alignment of the shafting; improved hangers with accurately finished bearings and automatic lubrication; and, of especial importance, the use of the rope drive for long-distance transmission in place of line-shafting. With these improvements it is claimed that power may be transmitted from source to machine with a total efficiency of approximately 80 per cent., divided about as follows: Rope drive, 96 per cent.; lineshaft, 85 per cent.; machine belt, 98 per cent.

Methods of Electric Distribution

Electric distribution is divided into group drive and individual drive. In the former case, electric energy is carried from the generator to a number of motors, which in turn drive lineshafts of varying lengths according to local conditions. From these power is delivered to the machines through belting, either by the use of countershafts or directly from the line as most convenient. In the case of individual drive each machine has its own motor connected by either belt or gearing and is, therefore, entirely independent. Among the principal advantages claimed for this method are the following: Elimination of lineshafting and countershafting, which must run continuously whether the machines are in use or not—an important item in shops where a certain proportion of the machinery is in operation only a part of the time; increased production, due to better speed control of individual machines; uniform speed under continuous operation, there being no fluctuation in speed of the lineshafting due to varying the number of machines in use at one time; a better arrangement of machinery for rapid production, and elimination of useless handling of stock, as machines may be placed without reference to lines of shafting; clear ceiling space, permitting the free use of cranes and hoists and improving both artificial and natural lighting; independence of each machine, there being no interference from accident to lineshafting or other machinery; greater cleanliness and better opportunity for the application of safety devices, and reduction of fire risk through the elimination of oily lineshaft bearings.

The principal disadvantage of the individual electric drive is the decrease in efficiency as the size of the motor is reduced; hence, this system makes its best showing in manufacturing establishments where fairly large amounts of power are to be transmitted. While motors of 75 to 100 hp. have average efficiencies ranging from 92 to 93 per cent., those of 5 hp. and less, such as are used largely for individual drive in a majority of cases, will have efficiencies running below 80 per cent. Some engineers consider 10 hp. as the economical limit for individual drive, and machines requiring less than this are grouped together and operated by motors of sufficient size to give a good efficiency, the power being transmitted to the various units by belting to lineshafts driven by the motors. This, however, applies to general cases, and there are many special instances in which it is advisable to use the individual drive for much smaller capacities.

Selection of Electric Motors

The selection of motors for industrial purposes is a matter of much importance and except for briefest mention is beyond the scope of the present article. All direct-current and alternating-current motors may be divided into three general groups—constant-speed motors, adjustable-speed motors and variable-speed motors. The first group is divided into direct-current shunt-wound motors, alternating-current squirrel-cage motors, alternating-current synchronous motors and alternating-current slip-ring motors.

The direct-current shunt-wound and alternating-current squirrel-cage motors are adapted to equipment requiring a low starting torque and practically constant speed, such as lineshafting, belted machines, constant-speed ventilating fans and centrifugal pumps. When employed in textile mills or woodworking plants where the air is filled with an inflammable dust, the squirrel-cage induction motor should be used, if alternating current is available, because, owing to its construction, there is no chance for sparking. If it is necessary to use the direct-current machine, it must be well inclosed.

The synchronous motor is commonly used in medium and large sizes and is well adapted to drives with light starting characteristics. The slip-ring induction motor s adapted to equipment requiring a heavy starting torque and constant speed, such as grinders and beaters in paper mills, ice machines, wood planers, brick machinery, etc. When alternating current is not available for this class of work the direct-current compound-wound machine should be used.

The second class, or adjustable-speed motor, includes the shunt-wound, compound-wound and multivoltage machines for direct current, and the multispeed induction motor for alternating current. The first of these is the most flexible and gives the most satisfactory speed control and the greatest steadiness of adjustment. It is especially adapted for the individual drive of machine tools and similar work where adjusted speeds are desired regardless of the load. When conditions are such that a heavy starting torque must be overcome, the compound-wound machine is called for. The multivoltage motor is not so extensively used as those previously described, the expense of more than two supply voltages making it prohibitive for general use. The multispeed alternating-current motor is of the squirrel-cage induction type and the change in speed is obtained by varying the number of poles. This machine is usually limited to four speeds and is employed largely for driving centrifugal pumps; ventilating fans, ice machines and similar apparatus.

Types of Variable-Speed Motors

The third class, variable-speed machines, includes the series-wound motor and the compound-wound with light shunt field for direct current, and the slip-ring motor and squirrel-cage induction motor for alternating current. The speed of any of these machines varies with the load, being high at light loads and decreasing as the load increases. The direct-current series motor has a high starting torque that gradually decreases as the motor comes up to speed. This machine is used for operating cranes, hoists, elevators, and other equipment calling for this special requirement. The compound-wound motor with light shunt field has similar characteristics, making it especially adapted to the operation of elevators where the starting load is heavy and the acceleration high and gradual. It is also used for driving punches and shears, sugar centrifugals and laundry extractors. The slip-ring alternating-current motor has characteristics similar to those of the series-wound machine for direct current and has a similar field of operation, which includes the driving of hoisting machinery of various kinds, dredges, steel mills, etc. The squirrel-cage motor is similar to the slip-ring type except for the fact that the resistance is fixed and cannot be varied; hence, the speed necessarily decreases as the load increases. This motor is particularly adapted to conditions where peaks of short or long duration occur periodically in a cycle of operation and where flywheels are employed to carry the load over these points. Shears, punches, hoists and reversing roll trains in steel mills are included in the field of this type of motor. Much depends on the proper selection of a motor for the particular work to be done, and when electric drive is to be used in a manufacturing plant great care should be given to this part of the equipment.

The heating and the ventilating of the building are so closely connected that they will be considered under the same heading. For industrial plants of large size there are three standard systems of heating—direct steam, direct hot water and hot blast. As compared with hot-blast heating, both direct steam and hot water have many of the same characteristics and may be considered together. As in case of many other kinds of equipment for a large plant, one particular system is not always best adapted to all buildings or all rooms, and a combination will often be found the most desirable when the entire plant is under consideration.

Objections to Direct Heating

The more common objections to direct heating for large shops and factory buildings are the large amount of radiating surface required, difficulty of temperature control and lack of ventilation. The first of these applies especially to large machine and erecting shops of considerable height, either with or without galleries, and provided with monitor roofs. In buildings of this kind the heated air naturally rises to the roof space, which produces a comparatively high temperature at this point and thus increases the rate of transmission through the roof. To overcome this it is necessary to provide heavy banks of heating surface near the floor along the outer walls, which in turn are liable to make it uncomfortably warm for those working near them. This condition may be relieved to some extent by placing a part of the coils overhead, but even with this arrangement the distribution of heat is uneven and roof transmission excessively large.

In buildings of several stories, of medium height, the distribution is better and the excess of warm air rising from the lower stories is often sufficient to take care of the roof transmission without providing extra surface for this particular purpose. In connection with a large plant there are often buildings and rooms where direct heating will answer all purposes and will be even better in some cases than the more expensive fan system. This applies especially to storerooms, packing rooms, carpenter and pattern shops, paint shops, etc., where the cubic space is large for the number of occupants. In rooms where there are disagreeable odors from chemicals or paints, the heating system should be supplemented by an electrically driven exhaust fan.

Hot-Blast System of Heating

For the main workrooms of shops and factories, especially those of considerable height and where the number of occupants is large in proportion to the cubic contents, the best results are secured by the hot-blast system. This gives an even distribution of heat, as the warm air may be directed to the points where it is most needed. In the case of one-story shops and foundries of the monitor-roof type the air may be discharged downward and at an angle toward the outer walls, thus maintaining a zone of warm air near the floor regardless of the temperature conditions in the upper part of the building. By drawing all, or even a part, of the air supply from outdoors, ventilation and heating may be combined without additional equipment.

As the latest theory of ventilation is based largely on the control of temperature and humidity, combined with air movement, it is a simple matter to combine all of these in a hot-blast system by introducing an air washer for the removal of dust and odors due to various manufacturing processes. With such equipment satisfactory results may be obtained in the average case by recirculating the air within the building, especially in the coldest weather, when the steam demands for both heating and ventilation are at a maximum. An arrangement that has given good satisfacton under actual working conditions has been to design the apparatus for recirculation within the building in zero weather and to admit fresh air in increasing amounts as the outside temperature rises. While special mention has been made of one-story buildings of the monitor-roof type, the hot-blast system is equally well adapted to buildings several stories in height by a proper design of the warm-air distribution system. In the case of foundry buildings, both supply and exhaust fans should be used for removing the vapor present when castings are being made.

As the heating system in a manufacturing plant is likely to be extended horizontally, the most satisfactory results are secured by a return-line vacuum system when direct steam is employed. This not only insures a positive return of the condensation without water-hammer, but also accelerates the circulation and makes it possible to operate the heating system without throwing additional back pressure on the engines. If hot water is used, it must always be under forced circulation in plants of this kind. This system of heating has proved very satisfactory in many cases on account of the ease with which the temperature of the buildings is controlled. All three of the systems mentioned use either live or exhaust steam, as most convenient, so there is no difference between them on this score. A selection is usually based on the general layout of the plant, the results desired and the funds available.

Eliminating Cylinder Oil from Exhaust Steam

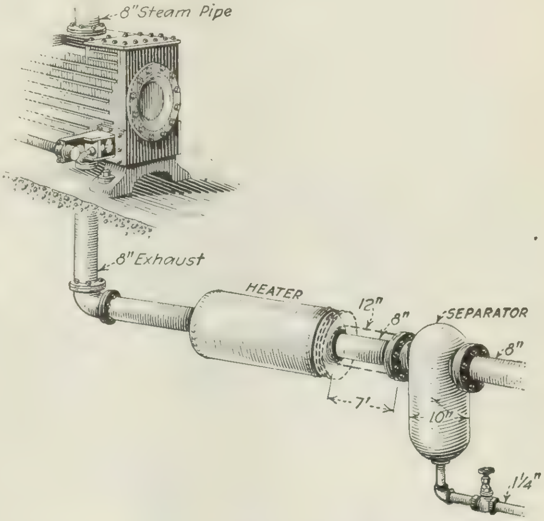
By W. H. Wakeman

In a certain manufacturing plant where a large portion of the shop is heated by the exhaust of the engine, the resulting hot water was allowed to flow into the sewer without the use of traps to prevent the escape of steam. As a measure of economy it was decided to return this hot water to the boilers, but this involved the use of a separator to free the condensate from oil. An 8-in. separator was accordingly installed, the maximum load on the engine being some 300 hp. The arrangement was as shown in the accompanying sketch. There was no trap on the 1¼-in. drip pipe. The engineer kept the valve partly closed, but it was always opened far enough to allow all the oil and water that were taken out by the separator to pass to the sewer. After the separator was installed, all hot-water returns from the heating system were pumped back into the boilers.

Subsequent boiler inspections showed that an objectionable quantity of cylinder oil was passing through the separator and entering the boilers. Suggestions were made to the engineer in charge to the effect that the separator was not properly located, that it was not the right kind for efficient service, that it ought to be taken apart and cleaned frequently, etc., but the boiler inspector insisted that the trouble was due to the fact that the separator was too small for the service required of it.

He maintained that not more than 90 lb. of steam per hour per square inch of pipe area should be forced through a separator. With a maximum load of 300 hp. and assuming 30 lb. of steam per horsepower-hour, an 8-in. separator with a cross-section of 50 sq.in. would pass $300 \times 30 \div 50 = 180$ lb. per hour.

In order to test this rule, the 8-in. separator was removed and a 12-in. of the same kind located in the same position. The 7-ft. length of 8-in. pipe between the heater and the separator was taken out and a 12-in. substituted, as shown by the dotted lines. No further changes were made, either in the equipment or in its operation, but the exhaust steam is now purified, so that no oil goes into the boilers; hence the experiment is pronounced a success and the correctness of the inspector's formula demonstrated.



SHOWING NEW CONNECTION BETWEEN HEATER AND SEPARATOR

Although moderate additions were made to stocks of petroleum in November, 1918, in the central and north Texas, north Louisiana and Rocky Mountain fields, the total surface reserve of crude oil in the United States, exclusive of California, was reduced during that month by about 3,500,000 bbl. On Nov. 30, 1918, stocks of petroleum in the fields to which this summary relates had been depleted to the extent of about 25,000,000 bbl., compared with the quantity in storage at the end of November, 1917.

The City of San Francisco has built and will operate a steam railroad 65 miles in length in connection with its famous Hetch Hetchy water-supply project. This is believed to be the first steam railway of any considerable extent to be built and operated by a municipality. The cost of the San Francisco railroad complete was approximately $2,000,000, and it is estimated that the city saved between $2,000,000 and $3,000,000 over what it would have cost to haul the material by truck.

When Doctors Disagree—II

BY JOHN S. CARPENTER

The engineer of the turbine plant locks horns with the builder's engineers over the question of the proper method of finding the stream flow and proves that the efficiency is below the guarantee.

Flossy came up to me after I told him how he fell down on the guaranteed efficiency and asked me where I took my degrees, if I had any. I tells that candy-covered cocktail that I got mine at the University of Hard Knocks, an' as fer degrees, I had about a hundred an' ten of the Fahrenheit variety an' not mentionin' ten or twenty of the Masonic brand. I guess my magnetic personality got him that time, the same bein' from takin' so much iron tonics an' then hangin' around them generators. He writes down a formula about the length of your forearm an' coyly murmurs, 'I suppose that you used this formula?' I looks at it an' snickers: 'What the Samhill's that?' He hands me a kinda queer look an' simpers that that's the latest formula by some Rooshian gent. I tells him, 'I s'pose I'm a bit behind the times, but my honest opinion of that is that it looks like the wedded name of a Rooshian vampire-lady after she married all the consonants in the Chinese alphabet. All Rooshia ever gave us is them Bolshevik fellers an' a lotta worry.'

"AN' THEN WE ALL WENT OVER THE TOP WITH FIXED BAYONETS"

"Along about that time another engineer comes in with a letter to me, the same readin' to the effect that our president had engaged him as reinforcements fer me, outa the office of a rival turbine company. I kinda liked that feller Johnson from the start, he bein' dressed like a human bein' an' smokin' a man's size cigar. After the introductions I says that we had better come into my office where we can finish the bout in private.

"When that feller Johnson checks over the figures of them two chorus men, it comes out that they kinda careless-like deducted the head due to the velocity of the turbine discharge water from the effective head, makin' about three feet less head on the wheels an' jumpin' the efficiency way up!

"Flossy protested against addin' in the discharge head an' said that they always did that an' that they considers it proper to do so. Johnson kinda sly-like says somethin' about some confidence men still sellin' gold bricks when they could get it across, an' then we all went over the top with fixed bayonets. When the smoke of battle cleared an' we had signed up an armistice, we got down to brass tacks. We agreed to:

"1. Make comparative weir, float an' current-meter tests.

"2. To check the pressure and vacuum gages against a mercury colyum.

"3. To take the wattmeter readin's as correct, seein' that the meters is new an' not likely to be much out.

"4. To take the generator efficiency curve as given by the builders.

"5. To settle all scraps by Marquis of Queensberry rules.

"The next question to decide was whose formula was to be used for the weir tests. If you count 'em careful, Bill, you'll find that they is as many of 'em as they is fake widows comin' to light when a rich bachelor cashes in his chips. Flossy trots out a formula invented by a Dutchman named Biel, as long as a wienerwurst an' havin' a temperature correction, but I tells him that it's outa the question to ring in any propaganda on this job on account of the new law what says we can't give no aid or comfort to the enemy. Johnson overrules me, sayin' that we can use it for comparison anyhow. Then Omar rips out another, the same bein' a second cousin or somethin' to the binomial theorem in the thirty-third degree, but we passes it up on account of the shortage of paper.

"I hollers pretty loud fer the good ol' Francis formula, an' we fin'lly agrees on that with a protest from that feller Johnson askin' me if it never occurred to me that water at 40, 50 an' 60 deg. acts like so many different liquids. I says, 'Sure thing.'

"Without any more doin's we got right to work an' built a light wooden bridge over the tailrace channel, an' marked the floor off in 5-ft. spaces at the edge. Then we put up light scantlin's at these spaces and marked them for every 2 ft. in depth of the channel. Then we took the current meter an' measured the velocity at every one of these points on the scantlin's an' goin' all the way acrost. Flossy made a cross-section of the channel an' connected points of equal velocity. Then we took each rectangle an' multiplied its area by the velocity, an' so on fer the whole cross-section. Addin' all these figgers together, we got the total water quantity; by dividin' the quantity by the total area, we got the alleged true average velocity of the water. But say, Bill, it ain't often that a guy like me ever gets what the sky pilots calls 'stings of conscience.' I could 'a saved the company the mere trifle of $200 by stickin' to my float tests, an' forgettin' that they ever was such a contraption like a current meter. With the current meter we got just about 2 per cent. less water than I did by my careful float tests."

"I heard tella people smokin' Camels, but why ain't the current meter the best an' most accurate way?"

"Bill, they is a lotta people which thinks they ain't nothin' that can touch a current meter, but let me tell you that a current meter is affected by local swirls an' eddies like a float is, an' while you're measurin' at some dinky little place an' takin' the hickey out to another, the conditions of flow may be altered in a wink by a gust of wind comin' along an' speedin' up the flow velocity. The ratin' curve of them critters must change with the kinda temperature it's workin' under, 'cause it's well known that metal works stiffer an' lubricants changes under different temperature conditions."

"But on any particlar job, the temperature is about constant durin' a test, ain't it?" says Bill.

"The devil it is! S'pose you go testin' early in the mornin', fer instance. The turbine is carryin' full load then, an' you work along until the dinner hour comes an' bats you in the slats. Does the temperature change durin' them times if you thinks of makin' a real current-meter test fer say half, three-quarters an' full loads? Besides that, them things has been known to kick over the traces an' change their ratin' without notice. That's why with all them uncertainties, you can't go too much on a current-meter test. That's why it's nice on paper to say we divided the channel off into spaces an' measured the velocity in each place, integratin' the whole an' gettin' the honest-to-goodness true average velocity. Wind, temperature and the pussunal habits of them meters all has to be considered. No, Bill, me fer a float test, but a real float! If the load changes between times, the timin' on that trip will show it. Temperature will not affect the thing, unless it gits froze in. Wind will shove it along or hold it back, but the timin' will show its tricks. When a feller says he made one o' them highbrow tests where they tried to split hairs, you ask him tactful-like if he is sure that none of the conditions changed durin' the test over the whole area of the channel, not even the head on the turbines. You'll see him look at you kinda queer an' ask if you b'lieve in ethics for engineers. As a partin' shot on this subject, let me tell you what Professor Schoder, of Cornell says, talkin' of subsurface floats: 'Careful work will give the discharge within 5 per cent. of the truth.' Now, for current meters, he says, 'Careful observations make it possible to obtain results within 5 per cent.,' if the banks are fairly parallel, etc., referrin' to rough streams; but with canals an' 'all conditions favorable, results within 2 per cent. of truth may be had by experienced observers.' Now, he assumes that nothin' changes during the time of test. The great point that you don't get is that a change in conditions shows up almost right away with a float test, but with a meter test where they measures every little strip of area, you may go on for maybe a half-hour on a big job before a change will show up, an' it's dollars to doughnuts that the change don't show up unless you repeat the test."

"Where did you get that dope that you blame on Professor Schoder? I wanna read it," declared Bill.

"Outa Marks' Mechanical Engineers' Handbook.

"Gittin' back to the story, after bein' all het up by your questions, the weir tests gave us 1½ per cent. less water than the current-meter test did. But after what I saw with those two weirs, I ain't got much confidence in weir tests unless they runs 'em off in still air an' the tests are made about the same time every day, so that the temperature is about the same on all of the tests. Fer, on the weir above the plant, when the wind was blowin', the sheet of water goin' over the weir was thinner than it ought to be accordin' to the formula an' the velocity was greater. We knew darn well that there was more water goin' over than what the formula would show 'cause we had a weir below the plant in a sheltered place, where the wind couldn't reach it, an' by the same formula, altho the weirs were of slightly different proportions, the discharge checked pretty close under similar conditions. Therefore, Bill, whenever you tries to spring a new weir formula on me, you gotta have a term in it that's allowin' fer wind or you better tell it to somebody else."

"FLOSSY SAID IT WAS BY THAT DUTCHMAN'S FORMULA"

"Did the engineers on that job seem satisfied with the weir tests, comparin' 'em against the meter and float tests?"

"Well, Johnson said that the weir tests always gave them a little higher efficiency on the same runners than when they was run by a meter or float test. The thing what them fellers was all the time wishin' fer was a pitot tube, which, so far as they knew, only had to be calibrated onct an' then it was set for good."

"How much do you think the temperature affected the readin's, an' is it worth while fussin' about?"

"Bill, them fellers had quite satisfied themselves that it didn't make over 1 per cent. in the ranges of temperature that we had to figger with. They didn't tell me just how they got to that idee, but Flossy said it was by that Dutchman's formula. They's another thing I forgot to say when I was rantin' about the current meter an' that is, an' the same applies to the pitot tube as well, that in the calibration of them critters they is towed instead of havin' the current butt against them like they does in actual use. This effect on the instrument is not the same an' is called DuBaut's parrydox. They is another source of error there that is not generally known, an' it's hard to say whether it's 1 per cent. or less.

"All the other points in our tests was settled in a peaceable manner an' without much discussion. The tests came out 78½ per cent. at full load which was rather discouragin' to the candy kids. But they died hard, an' with their boots on, the funeral bein' strictly private an' the announcements sayin' 'Please omit flowers.'"

The Electrical Study Course—Current Distribution in Three-Wire Systems

Takes up the subject of current distribution in the balancer machines and in the lines, for unbalanced conditions on the system, and proceeds to a discussion of the speed regulation of the sets.

IN THE preceding lesson we found that in a system such as that illustrated in Fig. 1 the total energy is obtained from the generator G. Also that when the system is balanced there is no current in N and that $I_1 = I_2$ and $I_A = I_B$, from which $I = I_1 + I_A = I_2 + I_B$. Under these conditions the directions of the currents are those indicated by the arrows. We will suppose that the loads L_1 and L_2 both consist of 100 lamps taking 1 ampere each, and that the current required to run the machines G_1 and G_2 idle is 5 amperes. We would then have $I_A = 100 \times 1 = 100$ amperes, $I_1 = 5$ amperes, and $I = I_1 + I_A = 5 + 100 = 105$ amperes, as shown in the figure.

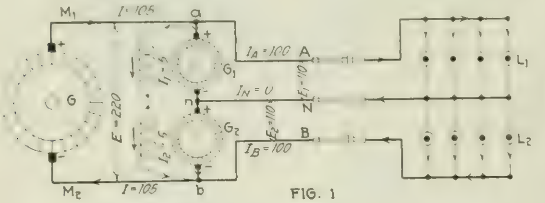


FIG. 1

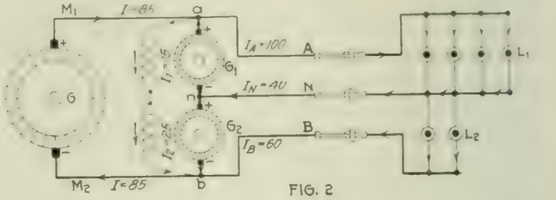


FIG. 2

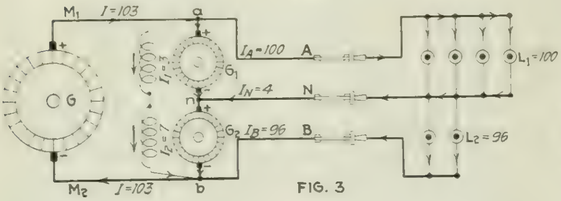


FIG. 3

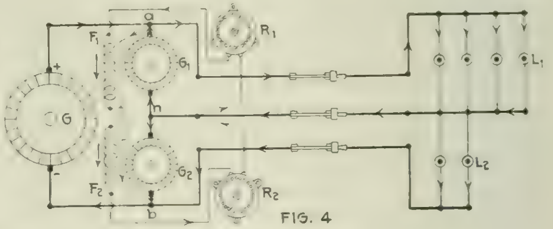


FIG. 4

FIGS. 1 TO 4 SHUNT BALANCER SETS CONNECTED TO A THREE-WIRE LOAD

The value of I could also be deduced directly from the load upon G. Thus, if the lamps were 110-volt ones, making the voltage across ab 220 volts, we would have as the load upon G twice 100 lamps of 1 ampere each at 110 volts plus the power required to run G_1 and G_2; namely, 5 amperes at 220 volts. That is, the load upon G would be $(2 \times 100 \times 1 \times 110) + (5 \times 220) = 23{,}100$ watts, and the current required of it would be $\frac{23{,}100}{220} = 105$ amperes, as previously found.

Assume now that 40 of the lamps of load L_2 are turned off. The total load upon G will then be 160 lamps plus the machines G_1 and G_2, which will make it $(160 \times 1 \times 110) + (5 \times 220) = 18{,}700$ watts, and the current required of G would be $\frac{18{,}700}{220} = 85$ amperes. The conditions as they would then exist are illustrated in Fig. 2. The value of I would be 85 amperes, as just found. The value of I_A would be $100 \times 1 = 100$ amperes, and that of I_B would be $60 \times 1 = 60$ amperes, making $I_N = I_A - I_B = 100 - 60 = 40$ amperes. The directions of these various currents are those indicated by the arrows.

Since I is only 85 amperes and I_A is 100 amperes, it follows that the difference, $I_1 = 15$ amperes, must flow through G_1 in the direction of the arrowheads. On the other hand, I_B is only 60 amperes, whereas I in M_2 is 85 amperes, which means that I_2 must be equal to $85 - 60 = 25$ amperes and must be in the direction of the arrowheads. The net result so far as G_1 and G_2 are concerned is that I_1 has changed from 5 amperes in one direction to 15 amperes in the other; that is, G_1 is acting as a generator delivering 15 amperes to the system, while I_2 has increased from 5 amperes to 25 amperes in the same direction, showing that G_2 is still running as a motor but under a much heavier load.

The sum of the currents through G_1 and G_2—namely, $I_1 + I_2$—is $15 + 25 = 40$ amperes, which is the value of the current I_N in the neutral wire. It might appear at first thought that this current should divide equally, 20 amperes going through each machine. The following explanation will make clear what happens:

When the load was balanced and the machines G_1 and G_2 were running as motors, they were taking 5 amperes and generating a counter-electromotive force somewhat less than the applied voltage, the latter being equal to 110 volts across each machine. Now, before machine G_1 can become a generator, its voltage must be increased to a value where it will be greater than its applied voltage or the applied voltage decreased in value until it is less than the generated voltage. In this case the latter is brought about by machine G_2 taking an excess current over that of G_1, when the load L_1 is greater than L_2.

First, assume that the load is unbalanced only 10 amperes; that is, I_A is 10 amperes greater than I_B. Then 10 amperes will flow along I_N and through G_2. This 10 amperes through G_2 will cause the voltage to increase between N and B and decrease across A and N, as explained in the preceding lessons. The decrease in voltage between A and N is just sufficient, in this case, to make the applied volts equal the generated volts of G_1, consequently no current is flowing through the armature of G_1. This brings about a condition where the set is taking just the same power from G as when both were running as motors. In the first case we had the two machines G_1 and G_2 taking 5 amperes at 220 volts, or $220 \times 5 = 1100$ watts; in the second case the power is all taken by G_2 at approximately 110 volts and 10 amperes, or $110 \times 10 = 1100$ watts as before.

Now, any further unbalancing of the load will cause the voltage between A and N to decrease below the generated voltage of G_1, and this machine will become a generator and deliver current to the load L_1. Since what the voltage decreases across A and N it must increase across N and B, it follows that after a condition is obtained where all the load has been transferred to G_2, any further unbalancing must divide equally between G_1 and G_2. Assume that the load L_1 is increased 30 amperes; this additional load divides 15 amperes through G_2 which causes the voltage to increase across this side of the circuit and decrease across G_1, so that G_1 becomes a generator delivering 15 amperes to L_1. In other words, 15 amperes flows from G through the additional load on L_1 and along the neutral back through G_2, which unbalances the voltage until G_1 becomes a generator and delivers 15 amperes to L_1. This gives $I_1 = 15$ and $I_2 = 10 + 15 = 25$ amperes.

On one side of the balancer set the power in watts $= EI = 220 \times 85 = 18{,}700$; on the other side the watts $= E_1$ or E_2 times $I_A + I_B = 110 \times (100 + 60) = 17{,}600$, which leaves a difference of 1100 watts not accounted for and at first thought may appear to be a discrepancy. But it has already been shown that G_2 was taking 10 amperes at 110 volts, or 1100 watts, before G_1 began to deliver any current. This represented the power necessary to drive the machines and must be added to the power supplied to the lamps, which gives the total watts delivered by G as $17{,}600 + 1100 = 18{,}700$, which checks up with the value obtained in the foregoing.

If the system is only slightly unbalanced, the current through the machine connected to the more heavily loaded side will not be reversed; it will merely be reduced. For example, if only four lamps were to be turned out in L_2 instead of forty, the conditions would be as follows: The current I_A would be 100 amperes as before, but I_B would be 96 amperes, making $I_N = 100 - 96 = 4$ amperes. This current would flow through G_2, which would throw the voltage out of balance to the extent that machine G_1 would take only 3 amperes from G, which would also flow through G_2. This added to the 4 amperes from N gives 7 amperes in the armature of G_2. In this case both machines would be running as motors, but G_1 would be taking 2 amperes less than the current required to run it idle, so that it would be imposing upon G_2 that much load. The current I in the main M_1 and M_2 would be computed exactly as before. Thus, the total load on G would be 196 lamps of 1 ampere each at 110 volts plus the machines G_1 and G_2, which would give $(196 \times 1 \times 110) + (5 \times 220)$ or $(3 + 7) \times 110 = 22{,}660$ watts or $\frac{22{,}660}{220} = 103$ amperes. Since I_A is only 100 amperes, it follows that 3 amperes must flow through G_1 from a to n, as was shown to be the case. Similarly, I in M_2 is 103 amperes, whereas I_B is only 96 amperes, thus requiring that 7 amperes flow through G_2 from n to b, which was also shown to be the case.

As a matter of fact the currents on unbalanced loads will not be absolutely of the theoretical values if the fields are connected as in Figs. 1, 2 and 3, because the voltage of one side of the system is below normal and that of the other above normal, causing each lamp across the one side to take slightly less current than it should, and each lamp across the other side slightly more than it should, so that the totals of the currents would not be exactly those figured. If, however, the excitation of the machines is accomplished as in Figs. 4 and 5, the voltages across the two sides remain practically constant under all conditions and the actual values of current will be very nearly the same as the theoretical. There will always be a small difference due to the fact that as the machines G_1 and G_2 become loaded the losses within them increase and these must be made up by current supplied from G. However, the difference is so slight that it may be ignored in practical computations.

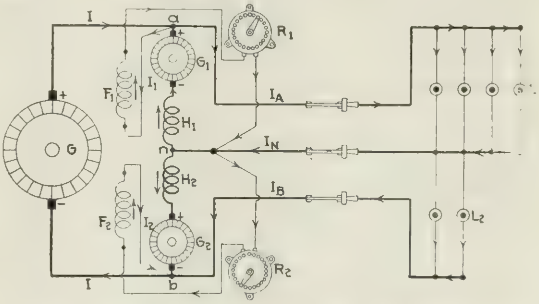


FIG. 5. COMPOUND BALANCER SET CONNECTED TO A THREE-WIRE LOAD

The next subject in order for investigation is the relation between the amount of unbalancing of the system and the speed of the balancer set. We shall consider the relation only in the systems which maintain constant voltage across the two sides; namely, those illustrated in Figs. 4 and 5, since those that do not maintain constant voltages are not in practical use.

Taking the case of Fig. 4, let us suppose that the load L_1 is greater than L_2. Then G_1 will operate as a generator driven by G_2 running as a motor. We know that when a shunt motor is loaded it slows down somewhat in order to reduce its counter-em.f. to the value required by the load. That is, $I_2 = \frac{E_2 - E}{R_a}$, where I_2 is the armature current of G_2, E_2 is the terminal voltage, E the counter-em.f. and R_a the armature resistance, showing that E must decrease if I is to increase. Since E can be decreased only by a reduction in field current or a decrease in speed, it follows that the speed must come down since the field current is constant so long as the line voltage is constant. However, in the case under consideration the conditions are considerably modified. When G begins to slow down G_1 must slow down with it, which causes its voltage to decrease. Now the voltage across *ab* is kept constant by the generator G so that if the voltage of G_1 decreases by a certain amount, that of G_2 must increase by the same amount. The decrease in voltage across G_1 would reduce the current through F_2, thus decreasing the excitation of G_2. Combining these effects, we find that at the instant the load is unbalanced the motor G_2 has a load put upon it that tends to slow it down, but it is prevented from doing so by the fact that as soon as it attempts to, the voltage across its armature is increased and the current through its field is decreased. The effect of either of these results is to cause an increase of speed, and their combined effect is such as to prevent any material drop in the speed.

When compound machines are used as in Fig. 5, the conditions are very similar to those that obtain with shunt machines arranged as in Fig. 4. A further discussion of the effect of the series field will be given in the next lesson.

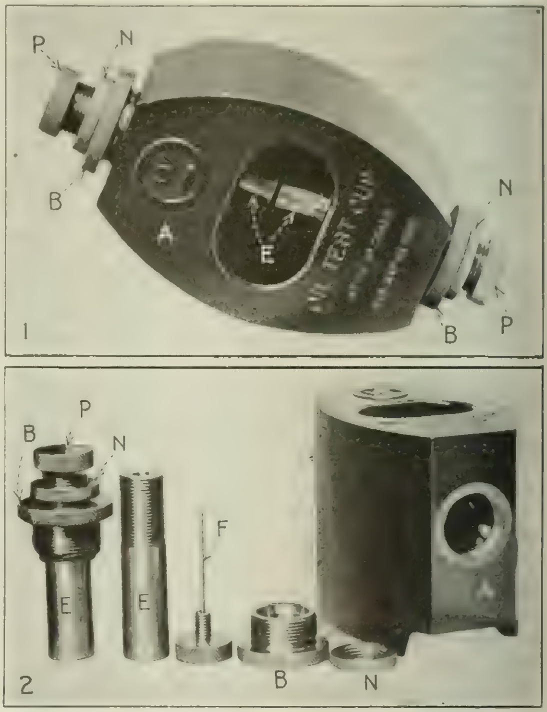
The last problem was to find the size of wire required for the mains from a generator to a balancer set $\frac{1}{2}$ mile away, if the line drop was not to exceed 10 per cent. when the load supplied was one of 100 amperes at 110 volts. If the total current is 100 amperes, each side of the system would have $100 \times \frac{1}{2} = 50$ amperes upon it, and that would be the current in the outside wires. If the maximum permissible line drop is 10 per cent. of the voltage at the generator, we have $E - 0.10E = 220$ volts, where E is the voltage at the generator and 220 volts is the voltage across the outside lines at the balancer. From this $0.90E = 220$, or $E = \frac{220}{0.9} = 244$ volts, and 10 per cent. of E is therefore $0.1 \times 244 = 24.4$ volts. The line drop is the line current multiplied by the line resistance, or IR. Since the current is 50 amperes, we have, $50 \times R = 24.4$, or $R = \frac{24.4}{50} = 0.488$ ohm. The line is $\frac{1}{2}$ mile long, which makes the total length of the two wires $2 \times \frac{1}{2} = 1$ mile, which is equal to 5280 ft. Consequently, the resistance of one foot would be $\frac{0.488}{5280} = 0.0000924$ ohm, and per 1000 ft. we would have $1000 \times 0.0000924 = 0.0924$ ohm. From the wire table we find that a No. 0 wire would be required.

In Fig. 5 the load consists of 100-watt 110-volt lamps. There are 800 in L_1 and 600 in L_2. The machines G_1 and G_2 take 20 amperes when running idle. What values have the currents I, I_A, I_N, I_B, I_1, and I_2, if the generator G maintains a constant voltage of 220 volts across *ab*?

Insulating-Oil Testing Cup

The only known satisfactory method of determining the insulating value of oil is to measure its dielectric strength by means of a spark gap immersed in the oil. Various devices requiring a comparatively large sample of oil and a rather high voltage for their successful operation have been used for this purpose. Consequently, there has existed a distinct demand for a device that would give reliable indications with a minimum sample of oil and with a relatively low testing voltage. A device for this purpose has been developed by the Westinghouse Electric and Manufacturing Co., and is shown in the figures. Fig. 1 shows the oil tester complete and Fig. 2 the various parts.

This new design uses a molded construction, so that the cup A is one piece. The molded part contains two brass electrode bushings B and is threaded to receive the packing gland. Back of each packing gland is a small amount of cotton packing, such as waste, which prevents oil leakage around the electrodes. The electrodes E are made from a cylinder one inch in diameter, threaded at one end to receive the locknut N. Binding posts P are placed on the outside end of the electrode to attach the leads from the testing transformer. A steel feeler gage E for setting the gap at exactly 0.1 in. is attached to one of the binding posts. The device has a cup-shaped interior to contain the oil substance to be tested, and the construction allows thorough cleaning without disturbing the gap setting.



FIGS. 1 AND 2. OIL-TESTER ASSEMBLY AND PARTS

The testing cup is light, compact and convenient. It weighs only 6.5 lb., with dimensions of 8.5 x 4 x 4.75 in., and requires only a 4-oz. sample of oil. The maximum voltage required for reliable testing is 25,000 volts. Higher voltages may be used if available, but it is seldom that higher than 30,000 volts will be required to discharge across the standard gap (0.1 in.) through any insulating oil.

Distillation of the oil shales found on White River, Utah, yields an average of 54 gal. of oil per ton.

EDITORIALS

Salvaging the Disabled

PROCEEDING upon the theory that an employer who gives a disabled man a job that is temporary and that requires no skill is not doing the man a favor but an injury, the Federal Board for Vocational Education at Washington has entered upon a program of constructive training which it is hoped will reach a large majority of the disabled soldiers and enable them to do just as effective work as their more fortunate comrades. Without such training to render them independent, there would be the ever-present danger, after the war has passed into history, of their becoming human derelicts.

It is estimated that sixty thousand disabled men will require aid in obtaining employment. Of these approximately thirteen thousand have already been discharged from hospitals and returned to a civilian status, and one of the immediate problems of the Board is to reach them. In the case of those yet to be discharged the problem will be somewhat simpler, as there is now the necessary organization and coöperation with the army to reach them.

Under the plan each man receives while in training sixty-five dollars per month if single and, if having dependents, such additional allotment as is absolutely necessary. Thus the proposition is rendered attractive enough to interest the disabled man; his acceptance being, of course, entirely voluntary. Moreover, in directing the training, efforts are being made to conserve, as far as possible, the man's pre-war knowledge and experience.

While industrial and commercial lines will undoubtedly absorb a large number of these men, the power-plant field offers opportunities which are not being overlooked by those having the work in hand; and the hearty coöperation of plant owners, managers and operatives is being sought.

A partially disabled man can be trained to render efficient service as a switchboard operator, a pump runner or attendant of other auxiliaries. In the boiler room with its stokers and modern appliances, special training and intelligence has replaced the requirements of brawn as of former days, and here is another opportunity for the partially disabled man. Also, he can be trained for work as clerk to the chief engineer in keeping records, plotting performance and figuring costs. Another occupation that is receiving special attention at the hands of the Board is that of electric welding, which is coming more and more into use in connection with power-plant work. In the engineering field in general, drafting and estimating offer attractive opportunities, and there are many other lines that could be mentioned.

In entering upon this work the Government is squarely meeting both an obligation and a social problem. It deserves not only support but active coöperation.

Why Repeal the Daylight-Saving Law?

DAYLIGHT saving proved so successful last year that it was felt in general that the practice had come to stay and that this year would see the law revised so as to make it effective throughout the year instead of from March to October. Some of the strongest opponents of the law came out openly in favor of it after one season's trial. Employers of labor everywhere were thoroughly convinced of the advantages to their employees, resulting from starting work one hour earlier in the morning and going home an hour earlier in the evening. Hundreds of thousands of people expressed themselves well pleased with the results, for not only did they have more time to get out in the open air in daylight, but their gas and electric bills were reduced. There resulted a saving of more than one and a half million tons of coal, an economy in this field far beyond expectations. The central-station interests also expressed the opinion that the law was beneficial.

In spite of all the benefit resulting from daylight saving, there has recently been such serious protests raised against the law from certain sections of the country that it has been seriously in danger of being repealed. Strange to say, these protests are coming from a class that will be least affected by the law, as they can generally adjust and arrange their working hours, irrespective of the clock, to best suit their conditions; but since they cannot see any advantage to themselves, even if they suffer no loss, they are opposed to a law that is beneficial to millions. It is gratifying to learn that Congress has let the rider, to repeal this law, attached to the agricultural bill, die, and those who fought to prevent the repeal of this law are to be congratulated on their good work for the public's interest.

If daylight saving during war time was economically correct and was beneficial to millions of people throughout the country, there is every reason for believing it is also economically correct during peace times. After a trial of a number of years several of the nations of Europe are again putting their daylight-saving laws into effect this year; in no case so far as we know are they being repealed.

During the winter seasons the central stations are all subjected to a very heavy peak load toward the end of the day, when the lighting load overlaps the industrial-power load. If the daylight-saving law is made effective the year round, the industrial load will be shifted far enough back practically to eliminate this peak, which will result not only in a saving in capacity to the central stations, but also in a saving of power to the industries. Then why not have daylight saving throughout the year? It is to be hoped that when the time comes to set the clock back next October, Congress will have made the law effective the year round.

Extending the A.S.M.E. Boiler Code to Other Pressure Vessels

THE revision of the Boiler Code of the American Society of Mechanical Engineers having been completed, it is possible that the committee may turn its attention to the formulation of codes for other pressure vessels, for which there is a demand, especially upon the part of those who are using the Code as the basis of state or municipal inspection.

To what class of pressure vessels should the attention of the committee be directed first? Service would dictate that immediate attention be paid to those classes of apparatus in the misuse of which the greatest danger lies. The wish to perfect a portion of the Code which is admittedly not up to the high standard of the remainder may lead the committee to devote its attention next to the Heating Section. A logical extension of its work upon steam boilers would be the formulation of a code for pressure heaters and economizers, in which field interesting problems await solution. And then there is the unfired-vessel field, some heated, as digesters, some the contents of which are capable of doing damage when released, as ammonia containers, gas tanks, etc. Some vessels are subjected or liable to be subjected to very high pressures, but have so little weight of contents and are capable of storing up so little energy that they offer little menace. On the other hand, systems containing large quantities of water under moderate pressure may, by a combination of conditions, accumulate a store of energy capable of disastrous effects if unintentionally released.

The committee has an interesting and useful work before it, whichever phase of the subject it turns its attention to next.

Activity and Accomplishment

TOO many men in executive positions have a distorted notion as to how time should be employed. They are of the opinion that subordinates should show continuous activity and be busy every minute of the working day. To them spare time on the part of a worker means laziness and leisure spells loss.

There are occupations in which temporary inactivity undoubtedly decreases output and so lessens profits, but they are usually positions in manufacturing establishments in which large production is maintained by specialized workers. The idea is wholly inapplicable to the power plant.

In a generating station or in a boiler room the main object is to keep the equipment operating at the required capacity. At the same time it is desirable that the plant be run with reasonable economy. To accomplish such results the working force is not obliged to be continuously on the jump, like so many waterbugs on a pond.

The best engineer is not necessarily the man who shows the greatest activity. There are occasions when the ability to move quickly and act surely and wisely are the most valuable qualifications an engineer can possess; but it is ridiculous to expect that he shall spend all the hours of his shift in sprinting around among his machines. There is such a thing as conservation of human energy.

The trouble is that a lot of folks fail to discern the vital difference between mere motion and actual accomplishment. They are pleased to see employees feverishly busy, but they never get to the point of analyzing what all that show of animation actually produces. By that very failure they miss great mental enlightenment.

If they catch the engineer enjoying a few minutes of leisure, they are apt to suspect that he is soldiering; or they may conclude that his position has so little real work connected with it that he ought to be given a few more odd jobs around the establishment. They are wholly blind to the truth that if the plant is running smoothly, leisure time is to be accounted for by the fact that every piece of apparatus is shipshape and in good repair.

If the plant employees are ceaselessly on the run, day and night, with oil can and wrench, adjusting, repairing, lubricating, fussing and perspiring in the effort to keep the wheels turning over, it is a safe bet that there is something wrong with the plant or with the attendants—and maybe with both.

The way to determine whether an engineer is an energetic whirligig or an economical worker is by the record sheet of plant performance and not by his rapidity of locomotion. A dog chasing his tail may form a veritable picture of liveliness and industry, but he produces nothing but yelps and a cloud of dust.

The review of the fuel conservation in Massachusetts by Mr. Hawley indicates that over three-fourths of the small plants in Boston were in good physical condition. If these are to be taken as fairly representative, they combat a very deep-seated conviction in certain quarters concerning the small plant. But the visits of the inspectors did show that most of these plants were sadly deficient in instruments that would enable the engineers to keep an intelligent record of the performance. This fact was confirmed by the New York Fuel Conservation, which found over sixty per cent. of the plants lacking such equipment. Yet during the war, by constant diligence the engineers were able to show remarkable savings in coal. This indicates what might be expected of many small plants where intelligent operation is combined with the proper instruments and equipment.

Newspaper Headline—NO BEER, NO WORK.

According to a news item thirty thousand members of the Essex, New Jersey, Buildings Trades Council will strike July first if war-time prohibition is placed in effect. Some people won't work without beer, and others won't work with it.

It is said that sixty days before the armistice was signed, Marshal Foch cabled to the Fuel Administration at Washington as follows: "If you don't keep up your petroleum situation, we shall lose the war." It looks as if the Fuel Administration had been on the job.

Americanization is the ingredient that will produce a strong, homogeneous alloy of the materials in our national melting pot.

Needless worry is as bad as a handful of grit in a can of lubricating oil.

· Correspondence ·

Lubricator on Air Compressor

In moving a large air compressor, the lubricator was accidentally broken and damaged beyond repair. When the piston was taken out, the cylinder and piston were found to be badly scored owing to lack of oil, so it was probably a good thing that the lubricator broke, as either it had not been working properly or someone had neglected to keep it filled. An old hydrostatic lubricator was found about the place, and I set about to fix it over to use on the air cylinder.

Fig. 1 shows such a lubricator as it is connected up for use with steam, and Fig. 2 shows how it was rigged on the air cylinder. The condensing chamber was taken off and the lubricator turned upside down and a connection from the discharge side of the compressor hooked in where the condensing chamber had been. The feed connection was turned down and connected into the top of the cylinder at midstroke.

The action is as follows: The air pressure enters from the discharge manifold, through the pipe *A* and tube *B* to the top (originally the bottom) of the lubricator and forces the oil out through the tube *C*, needle valve *D*, and on through the sight-feed glass and discharge tube into the compressor cylinder. The operation is positive from the fact that there is always an unbalanced pressure between the two connections because the compression pressure has only risen to about half the discharge pressure when the piston passes the discharge connection of the lubricator at midstroke, and from this point to the end of the stroke there is suction on this connection and there is always discharge pressure on the other connection. P. A. GETT.

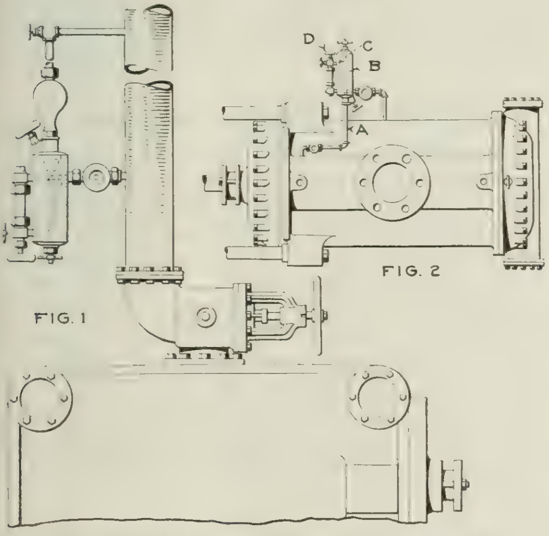


FIG. 1 FIG. 2

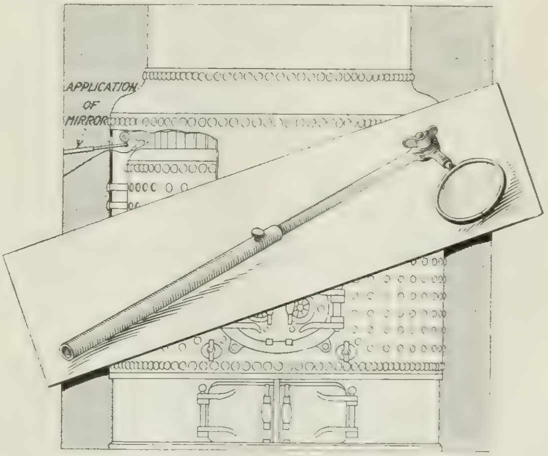
OLD AND NEW CONNECTIONS OF LUBRICATOR

New York City.

Plant-Inspection Mirror

Frequently, the operating engineer is called upon to inspect parts of equipment that are inaccessible because of their location or because of the interference of other objects. Therefore a reflecting instrument can be used to advantage for revealing these inaccessible views, much on the same order as the dentist's mirror.

I have made such a device, as shown by the sketch, the mirror being 6 in. in diameter, and the extension rod being of $\frac{3}{16}$- and $\frac{1}{2}$-in. brass rod. The mirror end is adjustable in any direction by means of a locknut that fastens it in its holder or by means of the swinging holder controlled by a thumb-nut. This instrument can be used in examining boilers, inaccessible pump seats, condenser shells, etc. M. A. SALLER.



INSPECTION MIRROR AND ITS APPLICATION

Philadelphia, Penn.

Observations of a Fuel Administration Inspector

In *Power* for Jan. 21, W. F. Remliw gives his observations of the plant of which I am in charge. If he had allowed the matter to rest with his observations, they could have been passed with but slight notice. But as he chose to draw conclusions and pass judgment on the plant, particularly on the operation of the boilers, after mere casual inspection, I feel that attention should be called to the unfairness of his criticisms.

First, it should be mentioned that his inspection was made on a Sunday, when the steam demand is very light. As the firemen are required to work very hard during weekdays and must keep their fires in good condition to carry the load, I do not think it out of place to be more lenient on Sundays with a light load and when there is no urgent need for them to keep breaking up the fires continually, as they must do during the other six days of the week. I cannot understand how anyone with fair judgment, after a casual Sunday observation with a light load, can make the statement that the plant is losing money instead of saving it, burning that fuel under those conditions. Any fair-minded engineer will feel that a statement like this, based on such superficial knowledge of conditions, is probably made with some other object in view than that of fair, impartial criticism.

For the benefit of this inspector I wish to state that the plant which he criticizes is saving money instead of losing it, and is operating on the same tonnage of mixed coal per annum that was required of the much higher-priced pea coal three years ago, before changing over to forced draft and No. 3 buckwheat.

In regard to his other criticisms—feed-pump location, open heater, and steam waste at the absorption machine—those conditions are well known to me, and application has been made to the authorities for funds to change them. In city work it has been rather difficult under war conditions to get funds for changes and repairs, as the inspector doubtless knows. When funds become available to obtain the material required for the work, no time will be lost in making these various desirable changes.

I ought to state that this inspector made his visit with a fireman unfamiliar with all the details of the plant and did not make known to me—the responsible party—the object of his visit. **M. F. Murphy.**

Brooklyn, N. Y.

Unsymmetrical Connections

In order to prevent field rheostats from becoming ground to earth, they are secured to the switchboard iron frame by means of insulated bolts and the operating end of the dial spindle is insulated from the contact end by means of an insulating coupling. That these precautions are not always observed is indicated by the following:

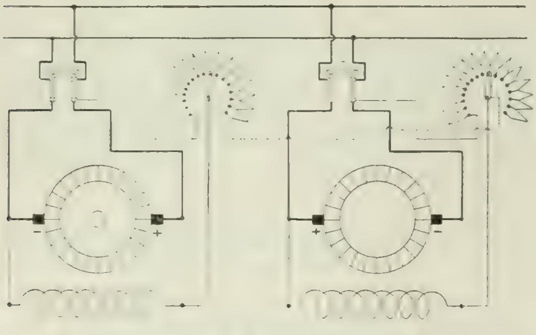


FIG. 1. CONNECTIONS WHEN TROUBLE OCCURRED

An attempt to parallel two exciters resulted in the circuit-breakers opening and brushes sparking, and the automatic voltage regulator was put out of order. An inspector found the regulator to be intact excepting that the relay contacts appeared to have been handling heavy currents. Fig. 1 indicates the cause of the trouble; here the dotted line shows the two field rheostats to be connected together as a result of their windings becoming ground to their frame and of mounting the two rheostats directly on the iron framework of the switchboard. Instead of connecting the rheostats to the same busbar, as indicated in Fig. 2, they were connected to busbars of opposite polarity, as in Fig. 1, so that the closing of the main switch of the incoming machine completed a short-circuit through the two rheostats in series, further complicating the trouble.

In order to right matters, the grounds were cleared in the rheostats, their frames insulated from the switchboard frame and the connections changed to those of Fig. 2, in which the two machines are shown to be connected alike in all respects. This indicates that two machines should not only have the same polarity when they are paralleled but should also be connected symmetrically so as to eliminate any complications that might arise from this source in case of trouble.

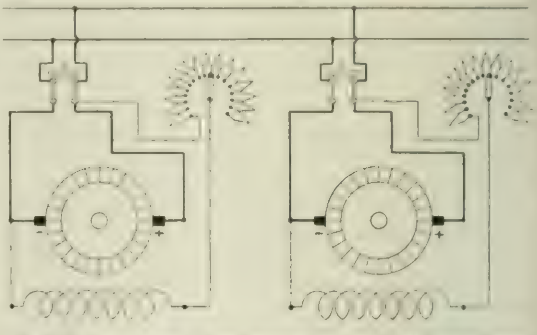


FIG. 2 CORRECT ARRANGEMENT OF CONNECTIONS

Brooklyn, N. Y. **E. C. Parham.**

Tallest Chimneys in the World

I was much interested in reading a description of the 525-ft. brick chimney erected at Washoe Reduction Works, and especially in the table giving comparative data of the largest stacks in the world, on page 808, of the Dec. 3, 1918, issue. The height of the Saganoseki chimney of Japan therein quoted is sometimes misreported, and I herewith desire to correct the figures as published. The stack was constructed under my management while engaged at the Saganoseki smeltery, and consequently I am acquainted with its dimensions. It is 550 ft. high above the footing and 567 ft. above the foundation level, 570 ft., hitherto often reported, being only a rough measure including the foundation. The other data which appeared in the table about the stack are all right.

Another tall chimney, which evidently has not been mentioned in your country and which was omitted in the article "Some Tall Chimneys" in your issue of Jan. 8, 1918, on page 56, was designed by the writer and was constructed at the smelting plant of the Hitachi mine, Japan, in 1915 to minimize the smoke troubles. It is constructed on a hill and is 700 ft. high above the charging floor. It measures 511 ft. in height above the foundation, 524 ft. above the foundation level, and at the time it was built it was the highest stack in the world. The other data of the stack are as follows: Material, reinforced concrete; volume of concrete, 320 cu.yd. for foundation, 310 cu.yd. for stack; weight of steel, 174 tons for foundation, 209 tons for stack; diameter of foundation, 85 ft.; inner diameter of chimney, 25 ft. 6 in. at top, 35 ft. 6 in. at bottom; thickness of wall, 8 in. at top, 24 in. at bottom; elevation of top above sea level, 1565 feet. H. MIYANAGA.

Ibaraki-Ken, Japan.

Vacuum Heating in Mild Weather

In vacuum heating systems the pressure should be decreased and the vacuum increased in mild weather and at night to "stretch out" the steam in the system, giving a lower pressure and temperature, thus radiating less heat.

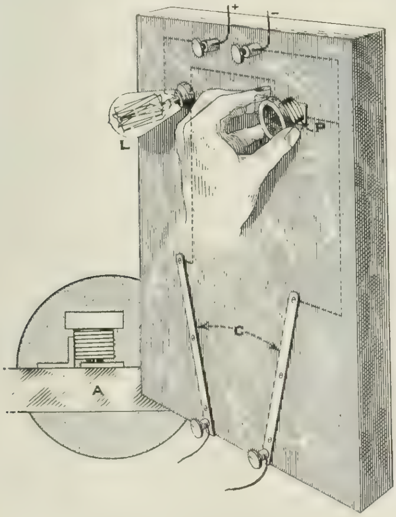
With the Paul system very good results can be obtained by shutting off the ejectors in mild weather and at night. W. T. MEINZER.

Brooklyn, N. Y.

Testing Outfit for Cartridge and Plug Fuses

I was much interested in the article, "Testing Cartridge Fuses," on page 282 of the Aug. 20, 1918, issue of *Power*.

The testing board that is shown in the figure is one that I built and used for a number of years with good results. It is made from a piece of 8 x 12-in. slate 7/8 in. thick. Contact strips *C* of 1/8 x 1/2 x 8-in. brass are placed so that the ferrules of the smallest cartridge fuse can rest on them at the bottom ends, and far enough apart at the top to make contact with the ferrules of the largest-sized fuse. Contacts *P* for testing plug fuses are made of a small brass angle and a flat strip placed about 0.5 in. apart, as indicated at *A*. Or a lamp socket may be used after flattening out the thread in the receptacle. A lamp *L* is connected permanently in circuit.



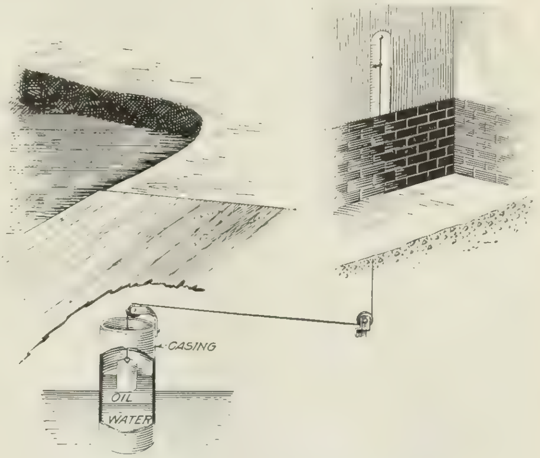
FUSE-TESTING BOARD

The board may also be used for making other tests by placing a binding post at the bottom end of each of the strips *C* and test leads brought out from them, as indicated. W. F. CONDON.

Detroit, Mich.

Preventing Telltale Float from Freezing

A simple kink that I use to keep our headwater float gage from freezing and becoming inactive in a hydroelectric plant is illustrated herewith. Hourly records are kept of the height of the headwater in the flume, and to do so a closed metal float is placed in a vertical piece of 6-in. pipe which is hung in the flume. A line from the float runs over the guide pulleys and connects to a marker that slides up and down on a graduated board attached to the side wall of the generator room, thus at all times indicating the height of the water.



NON-FREEZING TELLTALE FLOAT

To keep the float from freezing fast in the winter we put about two gallons of kerosene oil in the pipe and then recalibrate the gage, which works to perfection.

Deposit, N. Y. W. D. WAKEMAN.

Correcting An Erroneous Impression

We desire to bring to your attention an advertisement by the Baker-Dunbar-Allen Co. in the Feb. 4 issue, the text of which is highly misleading. The following matter inclosed in quotation marks are excerpts from the Baker-Dunbar-Allen Co.'s advertisement, each quotation being directly followed by our discussion:

"That was only one of the faults of the whole plant, and was one reason why the B. D. A. organization was called in to remedy this condition."

The Baker-Dunbar-Allen Co. was in no sense of the word "called in," but on the contrary requested the city for permission to bid on one of the minor contracts incident to general improvements to the Brilliant boiler plant, the plans and specifications for which work having previously been completed by the engineering force of the Bureau of Water, and at no time was the Baker-Dunbar-Allen organization called in, consulted or employed by the City of Pittsburgh in an advisory engineering capacity.

"Down in the Brilliant Pumping Station, City of Pittsburgh, they had two 500-hp. Babcock & Wilcox boilers in battery installed in such a way that the ashes had to be raked out of the ashpit by hand—obviously poor economy."

The Baker-Dunbar-Allen Co. were, being low bidders, awarded a contract by the City of Pittsburgh to move and reset on new foundations three 500-hp. Aultman-Taylor boilers. The amount of their contract was under 8 per cent. of the expenditures made to date on the general improvement scheme incident to the remodeling of a power plant in service twenty-five years and built prior to the era of modern economic power-plant apparatus.

"About the most ticklish job arising out of this problem was to move the boilers about 100 ft. horizontally and to lift them 7 ft. vertically onto a new foundation which provided ash gates of our own design under the ashpits of the boilers, permitting the direct discharge of ashes."

The boilers were actually moved 50 ft. horizontally and 3 ft. vertically.

The claim of having designed and installed special ash gates under these boilers is without the slightest foundation in fact, no such equipment ever having been considered or installed.

We feel that you will appreciate an opportunity to correct the erroneous impression conveyed to your readers by the advertisement mentioned, and to this end respectfully request publication of this letter in your columns.

F. W. LYON,
Division Superintendent,
Bureau of Water.

Pittsburgh, Penn.

Use of Turbine Blowers

The article on "Fans and Blowers in the Power Plant," by Rufus T. Strohm, in the issue of Feb. 4, contains no reference to the undergrate turbine blower that is so extensively used today for forced draft. There is a brief reference to a propeller-type fan, but it is stated that its use is similar to that of the disk fan, and Mr. Strohm makes absolutely no reference to the use of the propeller fan for delivering air against moderately high pressures, particularly for forced-draft work.

The publication of such an article creates certain impressions in the minds of readers, and the impression which many of them may be inclined to get is that the turbine-driven blower for undergrate draft is a rarely used machine, whereas it is quite the contrary; so much so that I believe there are far more small and moderate-sized isolated power plants today using these blowers than are using blowers of any other type.

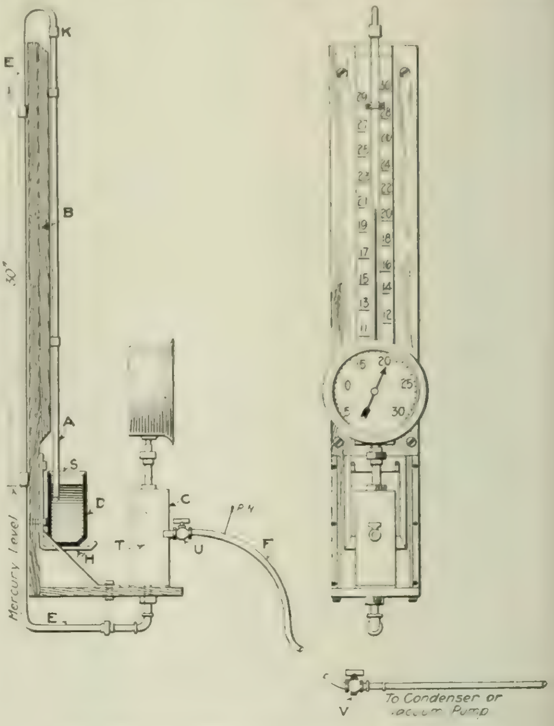
New York City. V. H. CARPLES.

Vacuum-Gage Test Column

The illustration shows a vacuum gage test board, an instrument seldom found in a power plant. This device can be made from material found about the plant. A description of the test board follows.

A mercury-column glass tube *A*, $\frac{5}{16}$ in. outside diameter, having a $\frac{1}{16}$-in. hole, and 34 in. long, is secured to the board *B*, as shown. To the shelf of the board is attached a short piece of 2-in. pipe *C*, plugged at both ends, the top end being tapped for a $\frac{3}{8}$-in. pipe and the bottom end for a $\frac{1}{8}$-in. pipe. In this piece of pipe is a bent tube *T*. It is bent for two reasons—to prevent anything from dropping into the pipe and so that in case of accident if mercury is drawn over from the mercury gage, it will collect in the reservoir.

Attached to the gage board is a bracket *H*, having oblong bolt holes so that it can be adjusted up or down to get the mercury level, the mercury being contained in a common drinking glass *D* covered with a cork or wooden covers. A pipe or rubber hose *E* is connected to the top of the mercury column and to the bottom of the cylinder *C*. If a pipe is used, it is connected to the glass tube by a rubber nipple *K*. Of course there must be a vacuum pump or condenser in the plant; if not, a vacuum gage is not needed. A test pump is eliminated, and so there is nothing to get out of order.



APPARATUS FOR TESTING VACUUM GAGE

To operate, attach the vacuum gage to be tested as shown and open the cock *V*. Then very slowly open the cock *U* just enough to start the mercury up into column *A*. When the mercury is at its height limit, shut the cock *V*, and if everything is tight the mercury will be at a standstill. Then connect the gage with the mercury column. For testing at various points, lower the mercury to any graduation and make a pinhole in the connecting hose near the cock *U*, and when the mercury drops to the point desired put a finger over the pinhole. In this way one can test a gage with a mercury column all the way down from zero to the limit of the gage. If there is a slight leak in the connection and the mercury will not stay up with the cock shut, open it just enough to balance the mercury.

Cos Cob, Conn. LOUIS G. O'DONNELL.

Because of the nature and extent of the equipment needed, the successful exploitation of oil-shale deposits involves large capital and technical chemical ability.

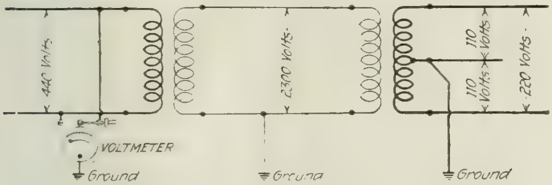
Inquiries of General Interest

States and Cities That Have Adopted the A. S. M. E. Boiler Code—What states and cities of the United States have adopted the A. S. M. E. Boiler Code? D. M. B.

The A. S. M. E. Boiler Code has been adopted by the States of California, Michigan, Minnesota, New Jersey, New York, Ohio and Pennsylvania, and is enforced independently of state laws by local boiler regulations of Allegheny County, Erie and Philadelphia, Penn.; Kansas City, St. Joseph and St. Louis, Mo.; and Detroit, Mich. In the City of Chicago, Ill., and in the States of Indiana and Wisconsin, boilers constructed in conformity with the A. S. M. E. Boiler Code are acceptable in lieu of the requirements of local laws and ordinances.

Ground Detector Voltmeter—We have a lighting system stepping up from 440 volts through a transformer to 2300 volts for transmission and then stepping down to 110-220 volts for lighting service. If a ground occurs on either the 2300- or the 110-volt line, will it indicate on the ground-detecting voltmeter on the 440 supply? E. K.

It is evident from the figure that a ground on either the 2300-volt or the 110-volt system will not be indicated on the ground-detecting voltmeter on the 440-volt supply, since each system is insulated from the other. However, the 2300-volt system should be kept insulated from ground, since a ground on the high voltage subjects the insulation between the primary and secondary windings to the full voltage of the transformer.



Testing Feed Water for Oil Received in Open Heater—How can a test be made to determine the amount of oil added to the feed water by an open exhaust-steam feed-water heater? F. P. H.

Make up about one pint of a concentrated solution of caustic soda and dilute with an equal quantity of water, using melted snow or ice water or the purest water conveniently obtainable. Provide two clean glass beakers and fill one about half full with a sample of the water received by the heater; mark the height on the side of the beaker and turn the water over into the other beaker. Refill the first beaker to the same point with a sample of the water discharged from the heater, and beginning with about 4 oz. of the caustic soda solution in a measuring beaker such as used by chemists and photographers, add sufficient of the soda solution to the sample of discharge water to cause it to become decidedly turbid, then add precisely the same amount of the soda solution to the sample of the water received by the heater. If the latter becomes turbid, repeat the experiment with perfectly clean beakers, each time using smaller equal quantities of the soda solution. This done, each beaker will contain the same quantity of soda solution and of the respective samples of water, and it may be noted how much engine-cylinder oil needs to be added to the beaker containing the sample of water received by the heater to bring it to the same appearance of turbidity as the contents of the beaker containing the same amount of water discharged by the heater and the same dose of soda water. This will not only indicate the presence of oil but, by repeating the experiment on a large enough scale, will demonstrate the ratio of the quantity of oil to quantity of sample water tested.

Repairs to Leaky Piston Valves—How can leaky piston valves be made tight? R. D.

If leakage is from wear or cutting of the valve seats they will need reboring and in nearly every case the packing rings will need to be replaced, for although the old rings may show no signs of cutting, they will be worn to shapes that will not conform to the rebored seats.

Tangye-Frame and Girder-Frame Engines—What is the meaning of "Tangye-frame" and of "girder-frame" engine? P. E. R.

The designation "Tangye" bed, or frame, is employed in American engine practice with reference to an engine frame such as illustrated by Fig. 1, consisting of a single casting *A B C* of ogee form for an overhung crank and resting full length on the foundation, with the main bearing at one end of the frame and the cylinder usually overhung and stud-bolted to the other end of the frame.

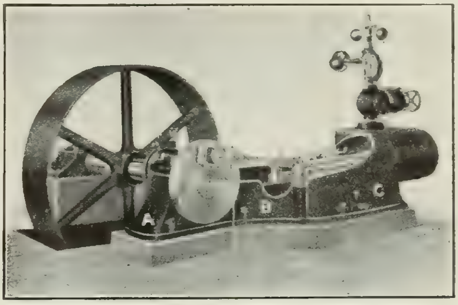


FIG. 1. TANGYE-FRAME ENGINE

The girder frame takes its name from the fact that the part of the engine frame *A B*, Fig. 2, between the main bearing and the cylinder, does not rest directly on the foundation, but acts as a girder, which usually is supported by a stand *C*, or legs, placed about the middle of its length. The cross-section of the girder frame between the guides and the main bearing generally is made in the shape of a letter T or channel beam to impart greater stiffness for the weight of metal used. The guides are most commonly part of the frame itself, either bored to a circular shape or planed V-shape.

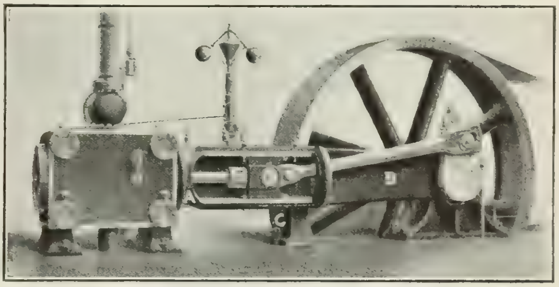


FIG. 2. GIRDER-FRAME ENGINE

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Lubrication of Air Compressors*

By H. V. CONRAD

SATISFACTORY lubrication of air-compressor cylinders is attained by securing the reduction of friction to a minimum and the elimination of carbonization of the oil as far as possible. For the proper reduction of friction the oil chosen should have sufficient body to sustain the weight of the moving parts and to form a seal between the piston rings and the cylinder walls, and still not absorb excessive power in the overcoming of the viscosity of the oil itself.

Carbonization of the oil allows the accumulation of deposits of carbon which are sticky in the early stages of their formation, but hard and flinty later. Such deposits accumulate on the cylinder valves, in the cylinder passages, in the pipes and eventually in the air receiver. Sticking or partial closing of the valves and their consequent failure to act properly is probably the chief objection to this action from the standpoint of the efficient operation of the compressor. The formation of excessive carbon deposits is apt to be due to one or more of the following causes: (1) The ill-advised use of some oil, such as a steam cylinder oil, which easily decomposes in the heat of the air cylinder; (2) the use of oils of too great a viscosity; (3) the use of too great quantities of oil; (4) the failure to provide a proper screen over the air intake of the compressor, thus allowing free entrance of dangerous dust (especially coal dust).

The objections to this carbonization aside from the sticking of air valves and choking of the air passages is the menace of fire. Particles torn loose from carbon deposits may become incandescent from causes which could not be anticipated by the compressor manufacturer. If such incandescent carbon particles should happen to come in contact with oil vapor given off by the lubricating oil, a fire might possibly be started whose menace would be small or large depending upon how much carbon had been allowed to accumulate in the compressor and piping to the receiver.

TABLE I CYLINDER TEMPERATURES AT END OF PISTON STROKE

Final Pressure of Air, Lb Gage	Final Temperature, Deg. F. Single-Stage	Final Temperature, Deg. F. Two-Stage	Final Pressure of Air, Lb Gage	Final Temperature, Deg. F. Single-Stage	Final Temperature, Deg. F. Two-Stage
10	145	...	100	485	243
20	207	...	110	507	250
30	255	...	120	529	257
40	302	...	130	550	265
50	339	188	140	570	272
60	375	203	150	589	279
70	405	214	200	672	309
80	432	224	250	749	331
90	459	234			

The selection of an air-cylinder lubricant is, of course, governed to a considerable extent by a knowledge of cylinder temperature it must withstand. Knowing the air pressures, the corresponding temperatures are ascertained fairly accurately, as shown in Table I. This table gives the final temperature in the cylinder at the end of the compression stroke, for single-stage, also for two-stage (or compound) compression, when the free air entering the cylinder is at 60 deg. F. Variations from these temperatures will occur in actual practice owing to water-jacketed air cylinders and radiation, tending to lower the temperature at the higher pressures. But at, say, 50 lb. pressure and lower, the heat is likely to be somewhat greater than given by the table, particularly if the compressor is run at high speed and also if it is not water-jacketed.

The natural inference of the reader after noting the temperatures in Table I is that he must select an air-cylinder oil whose flash point is higher than the maximum temperature likely to be encountered within the air cylinder. As a matter of fact, this is not the case and it need only be carefully noted that the study of the air-cylinder temperatures is useful mainly in testing lubricating oils to determine their resistance against breaking down into carbon, etc. But such temperatures cannot be taken as limits establishing the highest allowable flash point for a lubricant safe to use in the air cylinders.

For average normal conditions the oil should be a medium-bodied pure mineral oil of the highest quality, not compounded with fixed oils such as animal or vegetable, and should be carefully filtered in the final process of manufacture. Quite a range of oil composition is permissible for lubricants approved for this work, which are manufactured under the foregoing conditions. Primarily, a distinction must be made between those oils having a paraffin base as distinguished from those having an asphaltic base.

From a strictly operating standpoint—so it is claimed by some lubricant manufacturers—there is no distinction between these two classes of lubricants as to their desirability as compressor-cylinder oils, provided both have been properly filtered in the process of manufacture to remove the carbon-forming elements. If any carbon should be formed, however, such carbon deposited by the asphaltic-base oils is of a light fluffy nature and easily cleaned out, whereas that deposited by the paraffin-base oil is very adhesive and is characterized by a hard, flinty nature.

Merely as a guide to aid the operator in specifying the qualities to be possessed by an air-cylinder lubricant recommended for average duty, Table II is presented. It is suggested that those oils within the range expressed by the minimum figures be used for low-pressures and temperatures, while those expressed by maximum figures should be used for high pressures and temperatures.

TABLE II. PHYSICAL TESTS OF PARAFFIN-BASE OILS

	Minimum	Average	Maximum
Gravity, Baumé	28 to 32 deg.	25 to 30 deg	25 to 27 deg
Flash point, open cup	375 to 400 deg. F	400 to 425 deg F.	425 to 500 deg F
Fire point	425 to 450 deg F.	450 to 475 deg F.	475 to 575 deg F
Viscosity (Saybolt) at 100 deg. F.	120 to 180 sec.	230 to 315 sec.	to 1500 sec.
Color	Yellowish	Reddish	Dark red to green
Congealing point (pour test)	20 to 25 deg. F.	30 deg. F.	30 to 45 deg. F

It is recommended that any paraffin-base lubricant intended for use in all standard air compressors should meet the physical tests imposed by the average range of figures given in the middle column of Table II. The wording "standard air compressors" is to be interpreted as including the following types of machines: (a) Low-pressure up to 100 lb. compressors, which may be either small-sized single-stage units, or larger-sized compound machines; (b) high-pressure compressors which are constructed with the proper number of stages so that no excessive temperatures are ever reached.

The asphaltic-base group of oils is considered separately for the reason that the lower limit of gravity stated in Table II, namely, 25 deg. Baumé, eliminates this entire group from consideration—which is not the intention of this article. As a guide for the selection of suitable oil, Table III is given. For general all-around use, it is conceded that the recommendations given in Tables II and III cover the situation as well as possible, special cases, of course, requiring investigation and special consideration before making recommendations.

TABLE III. PHYSICAL TESTS OF ASPHALTIC-BASE OILS

	Minimum	Average	Maximum
Gravity, Baumé	20 to 22 deg. F.	19.8 to 21 deg. F.	19.5 to 20.5 deg. F
Flash point, open cup	305 to 325 deg. F.	315 to 335 deg. F.	330 to 375 deg. F
Fire point	360 to 380 deg. F.	370 to 400 deg. F.	385 to 440 deg F.
Viscosity (Saybolt) at 100 deg. F.	175 to 225 sec.	275 to 325 sec.	475 to 750 sec.
Color	Pale yellow	Pale yellow	Pale yellow
Congealing point (pour test)	0 deg. F.	0 deg. F.	0 deg. F.

The quantity of lubricating oil to feed to the air cylinders of compressors cannot be stated in exact terms due to the varying viscosity of different oils, the heat of compression and the size of cylinder. It may be stated in general, however, that after the cylinders have acquired smooth and polished surfaces, the quantity should be reduced to the lowest limit to avoid the possibility of the accumulation of carbon and sooty deposits within the system. The basis of quantity given in Table IV is recommended, subject to modifications already mentioned, for these cylinders or equivalent sizes operating under normal conditions.

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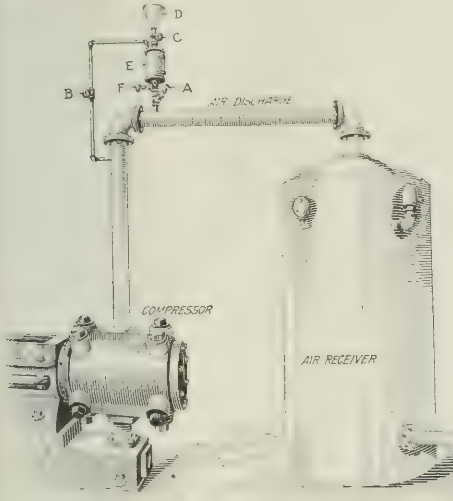
*Abstract of a paper prepared by the Compressed Air Society.

The results in the last column of Table IV are based on the assumption that under average conditions of temperature and usual range of oil viscosities, a pint of oil will contain an average of about 16,000 drops. These figures are offered merely as an approximate guide.

TABLE IV. QUANTITY OF AIR-CYLINDER LUBRICANT REQUIRED PER 10-HOUR DAY

Size of Cylinder, In.	Displacement per Minute Cu.Ft	Piston Speed, Ft. per Min	Sq.Ft. of Cylinder Wall Swept by Piston	Drops of Oil per Min.	Drops of Oil per 10 Hr.	Sq.Ft. Oiled per Drop	Pints of Oil per 10 Hr.
8x 8	120	344	718	1	600	718	0.0375
12x12	320	408	1230	2	1200	613	0.0750
18x18	880	496	2340	4	2400	585	0.1500
24x24	1/30	550	3450	6	3600	575	0.2250
30x30	2940	600	4700	8	4800	590	0.3000
36x36	4550	644	6070	10	6000	607	0.3750
42x42	6700	696	7600	12	7200	633	0.4500

A leading authority on compressor engineering contributes the following: "The best way to determine the proper amount of lubrication is to take out the valves from time to time and examine the cylinder. All parts should feel that there is oil thereon. If they feel dry, the lubricators should be adjusted to feed a little more oil, whereas if oil lies in the cylinder and its parts show excessive oil thereon, the quantity fed by the lubricators should be reduced. By thus examining the machine a few times, the proper amount of oil can be determined to suit the characteristics of the particular lubricant used and the conditions under which the machine operates."



DEVICE FOR CLEANING CARBON FROM DISCHARGE LINE AND RECEIVER

The best of lubricating oils will deposit enough carbon in the compressor system to necessitate periodical cleansing. For the removal of carbon, the machine operator should confine his efforts to the use of soapsuds. A good cleansing solution is made of one part of soft soap to fifteen parts of water. The suds should take the place of oil for a few hours, and be fed into the air cylinders about once a week, either by means of a hand pump or through the regular lubricator about ten times as rapidly as oil. The cleanliness of the air valves when inspected, as they should be periodically, will indicate whether greater or lesser applications of the soapsuds should be made. After using soapsuds, open the drain cock of the air receiver, and of the intercooler in the case of compound machines, to draw off any accumulated liquid. Oil should be used again for a half-hour before shutting down the machine in order to prevent rusting the cylinder and its fittings. Never use kerosene, gasoline or lighter oils in an air cylinder for any purpose, because of their volatile nature.

It often happens that oil, carbon and other foreign matter are deposited in the air-discharge lines and air receiver. A practical method of cleaning these is shown in the illustration, where a compound chamber made of 6-in. pipe is shown set on top of the discharge pipe. If a mixture of 1 lb. of Red Seal lye and 18 lb. of water is passed into the discharge line at the rate of 60 or 70 drops per minute while the compressor is running, it will eat out the accumulation on the surface of the pipe and in the receiver, and if the blowoff valve on the receiver is open, all this foreign matter will be discharged therefrom. To use the compound, close the cocks *A* and *B*, open the valve *C*, and pour the lye mixture into the funnel *D*. When the chamber *E* is filled, close the valve *C*, open the cocks *B* and *A*, and regulate the feed by the valve *F*. The cleaning solution can be used every month or two or, depending on how much accumulation there may be in the receiver.

Approximately four times as much oil will be needed in the steam cylinders as in those for air, subject, of course, to variable local conditions. Depending on its viscosity, a pint of steam-cylinder oil will furnish from 5000 to 8000 drops. Taking an average of about 6500 drops, and four times as much oil as air cylinders of same size, and working at same piston speeds, as given in Table III, the recommended amounts to feed the steam cylinders or their equivalents are given in Table V. These figures are approximate only, and will vary with the steam conditions, the kind of oil used and its method of introduction into the steam, also with boiler compound carried by the steam into cylinder.

TABLE V OIL REQUIRED FOR STEAM-CYLINDER LUBRICATION

Size of Cylinder, In	Drops of Oil per Min	Pints of Oil per 10 Hr
8x 8	4	0.4
12x12	8	0.75
18x18	16	1.5
24x24	24	2.25
30x30	32	3.0
36x36	40	3.75
42x42	48	4.5

Detroit Engineers Approve Proposed Registration Bill

The subject of the registration of engineers has been under consideration by the Michigan Engineering Society for several years, and a bill designed to accomplish that end was presented at its last annual convention and was afterward submitted to an informal conference attended by about twenty-five representatives of the various architectural and engineering societies of the state, and after extended deliberation and discussion was redrawn and approved. The bill has been introduced in the state legislature, and probably final action will be taken soon. At its meeting on Feb. 21, the Detroit Engineering Society indorsed the revised draft of the bill. The proposed act:

1. Provides for the voluntary registration of any engineer now engaged in the practice of the profession, in whatever branches thereof he may prove himself qualified.
2. Provides for the compulsory examination, classification and registration of all persons hereafter desiring to begin practicing as architects or engineers, and establishes a minimum standard of qualifications for such persons.
3. Supersedes the existing architects' registration law and subjects the architectural and engineering professions to the same general regulations, with appropriate tests for each.
4. Provides a board of registered architects and engineers for the administration of the law.
5. Does not restrict any person now engaged in practice as an architect or engineer from continuing so to practice, except in public work.
6. Does not require any such person to be examined or registered unless he uses the title registered architect or registered engineer.
7. Does not require registered architects to register until 1921.
8. Does not prohibit the performance of architectural or engineering work by anyone not calling himself architect or engineer.

When Coal Oil Johnny Goes to Sea*

THE fast clipper ship was built of wood and propelled by sails. We had the timber to build that type of ship and the ingenuity to apply wind power and beat the world in speed. Those were the days of the Yankee clipper ships, and from Revolutionary times until 1861 we carried from 60 to 90 per cent. of our own world trade. John Bull took first place in the new kind of shipping. The proportion of American trade carried in American ships steadily ran down to less than 10 per cent. at the outbreak of the world war. Today we are about to see another revolutionary advance in merchant ships, and the United States will again have some advantage—if we back natural resources with national ingenuity.

Petroleum is the coming factor in shipping. It will be used under boilers to raise steam. Better yet, it will propel internal-combustion engines of the Diesel type—the motor ship. We have an advantage in our large output of petroleum—65 per cent. of the world's output. And we are handiest to Mexico's supplies, now nearly 8 per cent. of the world production, with remarkable possibilities for increase and two types of crude oil that are peculiarly suited to marine use.

Petroleum is about to effect a transformation in world shipping much more remarkable than that which was wrought by steam. The possibilities are fascinating. Both the oil-burning and the motor ship remove handicaps under which the merchant navies of the world have been steadily degenerating. They reduce operating costs, increase range and flexibility, overcome certain international political handicaps in shipping, and improve the living standards and morale of those who go down to the sea in ships.

When Coal Oil Johnny steps aboard a merchant ship and takes charge of the engine room the transformation is great. The comparatively few shipping managers who have operated with petroleum will tell you that it is like switching from the one-hoss shay to a high-powered racing car.

Take the advantages found in the oil-burning ship with steam engines over the coal burner. There is a reduction in the number of men needed in the boiler room, first of all. Next comes reduction in bunker space, with an increase in cargo space. A ton of oil takes 5 cu.ft. less space than a ton of coal and gives 80 per cent. steaming efficiency against 65 per cent. for coal. This works out to about 40 per cent. saving in bunker space, which is made available for cargo in a freighter. Moreover, there is a saving in quarters for the crew, because an oil-burning ship carries fewer men.

Oil-burning vessels will make from 10 to 20 per cent. more mileage than coal burners. There is better control of steaming, because fires can be started and stopped instantly, steam raised quickly and time in port saved through the greater ease of taking on oil as contrasted with coal. There are other advantages: Oil is often cheaper than coal in actual dollars—prices vary widely, of course. Oil does not deteriorate in storage like coal. Oil eliminates the fire risk from spontaneous combustion in coal, and is not subject to the danger of shifting in rough weather at sea. Oil eliminates ashes and ash conveyors, smoke and soot and the necessity for frequently painting a ship. Oil reduces the expense of grate repairs, corrosion of boiler plates, fuel-handling devices afloat and ashore.

The oil burner has a radius of from two to three times that of the coal burner. Fast passenger liners burning oil for steam could almost make the round trip from New York to Europe and back, taking most of their oil on this side; and with freight steamers running at slower speeds and burning less oil to the mile, it would be possible for them to go half round the world.

Coal Oil Johnny can give almost any coal-burning steamer seven-league sea boots by a few simple changes in equipment—the installation of oil burners under the boilers and the conversion of coal bunkers or double bottoms into oil tanks. But even that is only half his potential efficiency. Look a little farther ahead and design your ship to run with internal-combustion engines of the Diesel type, and he can double the efficiency.

The motor ship will operate on about half as much oil as the oil-burning steamer. Its engine-room force is reduced still more—from one to three men are sufficient; and there are no stokers, for the motor ship's mechanical staff is made up of skilled men. With the world's merchant fleets equipped entirely as motor ships, from 80 to 90 per cent. of the bunkering stations around the globe could be abolished; ships would require fuel only about twice in going around the world—or at an average of every six weeks. There need be no isolated fuel stations; oil would be taken on only where ships called for cargo or passengers.

Anyone who has made a voyage through the Tropics will find it interesting to contrast this sort of ship with his recollections of coaling incidents. If his voyage was through the Suez Canal to Australia or India, for instance, he remembers the terrific heat and how only Chinese coolies can stand the temperature of the fire hold; and how the ship was coaled at Port Said by hundreds of women carrying baskets of fuel. Neither the motor ship nor the oil-burning steamer requires coaling. The engine room of a motor ship need be little warmer than the deck in the Tropics; and, besides, there is probably only one man attending the engines, and he is not performing hard manual labor nor is he in dirty surroundings.

The boiler room of an oil-burning steamer can be 25 deg. cooler than if coal were burned under the same boilers. For most of the heat in a fire hold comes from opening the furnace doors to throw in coal. There are no furnace doors when oil is burned. With coal, heat escapes every time the furnace door is opened and is lost for steam-making purposes. With oil, there is no furnace door to open and more of the heat is used for steam making.

With the motor ship we can have an entirely new era in ocean transportation. It calls for skill and effects economies that will yield good wages; and its flexibility and speed should facilitate rearrangement of the world's shipping routes, so the seaman may get home more frequently and have a home worth getting to. The motor ship is here. But it still needs development and application. Thus far it has been built chiefly in small-tonnage freighters running at moderate speed. These have been highly successful economically; but there are still certain shortcomings in machinery and organization to be dealt with.

The Diesel engine must be freed of some defects that have appeared under the stress of ocean voyages, and must also be built in larger units to furnish greater horsepower for bigger ships running at higher speed. The problems are now entirely questions of engineering, and American ingenuity should prove adequate to develop the fast motor liner for passenger traffic.

If the world should turn during the next 10 years from coal to fuel oil, and from steam to the motor ship, the question of petroleum supplies will become important. At present the largest marine consumption of petroleum in the world is probably that of the United States Navy, estimated at 5,000,000 bbl. yearly under war conditions. This quantity would not go far in operating an American merchant marine of 25,000,000 tons. Data upon which to figure consumption for such a fleet, with types of passenger and cargo ships running at various speeds and in various classes of service, are not yet very ample. But engineers have adopted a rough-and-ready ratio, estimating 1 ton of oil yearly to a ton of dead-weight shipping, where the fuel is burned for steam, and half a ton yearly for motor ships.

On this basis the American merchant marine alone would require 150,000,000 bbl. yearly for steam, or 75,000,000 bbl. for motor ships. The world's ocean tonnage was 50,000,000 tons before the war, and under the improvement and cheapening in transportation, made possible through petroleum, might increase to 75,000,000 tons within the next five or ten years, this estimate including our own merchant marine. Thus, for 75,000,000 tons of motor ships there would be required yearly somewhere between 200,000,000 and 250,000,000 bbl. of crude oil. This is approximately half of the world's total present production, and more than 80 per cent. of our own production.

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*Abstract of a bulletin by Edward N. Hurley, Chairman United States Shipping Board.

Where is the oil to come from?

Fortunately, nature has stored supplies in the earth for precisely this situation. Mexican petroleum is peculiarly suited for marine use. In the district round Tampico, which has been the scene of petroleum development for the past 18 years, there are two types of crude oil taken from opposite side of the Panuco River, which runs through Tampico and divides the district. The northern type of oil is a heavy crude oil that cannot be refined, but is suitable for burning to make steam. The southern type of oil is lighter. When refined this yields about 12 per cent. of crude gasoline and is suited for Diesel engines. No such oil field has yet been located in any other part of the world. The Tampico district now has about fifty wells in production with an estimated capacity of 1,500,000 bbl. daily—more than twice as much oil as would be needed to operate the world's merchant fleets and navies.

It is true that Mexico at present produces only from 50,000,000 to 60,000,000 bbl. yearly; but this represents simply the quantity that can be handled in available pipe lines and tank steamers. The Tampico district is less than 150 miles long and 50 miles wide; but it lies over enormous reservoirs of oil and is considered but part of a general oil region 1600 miles long and from 75 to 100 miles wide. Prospectors have also found promising oil indications in Guatemala, Venezuela, Colombia, Ecuador and other parts of Latin America.

Political unrest in Mexico is still a serious handicap to oil production, the construction of new pipe lines and port facilities, and the investment of additional capital by outside operating companies. But by the time the world's improved merchant fleets are ready for the transformation of petroleum, it is to be hoped that Mexico will have worked out political stability. The petroleum lies beneath her soil. Its efficient use means not only wealth to her but benefit to all nations.

Again Water-Power Legislation Fails

The proposed water-power legislation which has been before Congress for the seven years of the present Administration failed of passage when Congress expired sine die Mar. 4. After lengthy debate in committee and on the floor of both houses, conferees on the part of the House and the Senate agreed to favorably report the bill, which would undoubtedly have passed both houses if it could have been reached on the calendar before the expiration of the Congress. The proposed legislation did pass the House of Representatives a few days before the end of Congress by vote of 264 to 65.

The proposed legislation failed to pass in the Senate, however, because it became entangled in the meshes of the filibuster which was conducted by Senators who are opposed to the President's policy as to foreign affairs. Although there were informal assurances to Senators who had charge of the proposed legislation that there were at least 80 votes in favor of the measure in case it could be brought before the Senate, the bill did not obtain a hearing because of the filibuster, which prevented this and many other important proposed laws of vital consequence to the development of industrial America.

It will now be necessary for the advocates of water-power legislation to begin to open a campaign of education for the benefit of the new members of the House of Representatives and Senate.

Obituary

Malcolm Gifford, president of the Gifford-Wood Co., of Hudson, N. Y., died on Mar. 5 after an operation at a sanitarium in West 61st St., New York City. He is survived by his widow and two children.

Personals

T. E. Butterfield, Associate Professor of mechanical engineering at Lehigh University, is back after service on the teaching staff of the Post Artillery School at Fort Monroe, Va., where he held the rank of major.

Martin T. Hooper, formerly supervising mechanical engineer to the officer in charge of construction, Langley Field, Hampton, Va., has resigned to become assistant to the superintendent of machinery of the Virginia Shipbuilding Corp., Alexandria, Va.

Engineering Affairs

The American Electro-Chemical Society, Pittsburgh section, will hold a meeting on Mar. 14, at which many important papers will be discussed.

The New England Waterworks' Association will hold a meeting on Mar. 12 at the Hotel Brunswick, Copley Square, Boston, Mass.

Bridgeport Association No. 4, of Connecticut, held its annual banquet at the Stratfield Hotel, Thursday, Feb. 27. The attendance included the ladies. There was an entertainment, and dancing concluded the festivities.

Business Items

Schaeffer and Budenberg have opened an office at Tulsa, Okla., with T. C. Eales in charge as local manager.

John G. Robel, Inc., has moved its offices from 608 So. Dearborn St. to the Garland Building, 58 E. Washington St., Chicago.

The Dearborn Chemical Co. has opened an office at 206 Commerce Trust Building, Kansas City, Mo., with G. M. Massen and W. H. Fairlamb, who are the company's representatives in that territory, in charge.

The Morse Chain Co. announces the removal of its Kansas City offices from the R. A. Long Building to more commodious quarters at 211-212 Finance Building, with W. V. Warner as district manager in charge.

The Chicago Pneumatic Tool Co. announces the removal of its Cleveland district office from Room 813 to Rooms 406-408 Engineers' Building. Ross Watson, district manager, will gladly welcome visitors to the new offices.

The Standard Oil Co. at its Whiting refinery will equip its 21,000-hp. boiler with a full-load capacity of 40,000-hp. The company is also installing a new refrigerating plant with a daily capacity of 400 tons. Other improvements include a new coal bunker 200 ft. wide, 1000 ft. long and 25 ft. deep, with a capacity of more than 125,000 tons.

The Factory Products Corp., New York City, has become associated with the Engineers' Corp., a subsidiary of the J. G. White Engineering Corp., for the special purpose of exporting American machinery and building products. The trade connections of the consolidated corporation are extensive, and its policy is to infiltrate existing markets thoroughly with American goods before expanding to new quarters of the world.

Trade Catalogs

The Baker-Dunbar-Allen Co. of Pittsburgh, Penn., has issued Bulletin A descriptive of its ash gate for underfeed-stoker practice. Copy may be had from the company free upon request.

Foster Waste Heat Type Marine Superheaters—Power Specialty Co., New York City. Bulletin M-2, Pages 32, 6 x 9 in. A booklet of general instructions containing useful information on this type of superheater.

"A Chain of Evidence" is the title of Bulletin No. 16, which is the fourth of a series issued by the Morse Chain Co. of Ithaca, N. Y. This is subtitled "Small Power Drives," but embraces medium power drives between 5-hp. and 200-hp.

The Combustion Engineering Corp., New York City, has just issued its Type "H" Stoker Bulletin H-1. It covers automatic stokers for all kinds of industrial and heat-treatment furnaces. A copy of this bulletin may be had free upon request.

Coppus Centrifugal Turbo Boiler Feed Pump. Coppus Engineering and Equipment Co., Worcester, Mass. This catalog contains useful information under the subtitle, "A New Development in Boiler Feed Pumps," and may be obtained from the company free upon request.

"Dixon's Graphite Products" is the title of a new pocket catalog issued by the Joseph Dixon Crucible Co. of Jersey City. While not so complete as the large general catalog, it furnishes a good idea of the variety of products made by this old concern. Pages have been devoted to lists of articles especially for mills, railroads, automobiles, etc. The descriptions are brief, but the company will gladly send pamphlets dealing in detail with any of the individual members of the line. This new catalog should be in the file of everyone who has occasion to use lubricants. Ask for Booklet No. 94-KP.

The Ingersoll-Rand Co., Easton, Penn., has issued the following: Form 9120, 4 pages, 6 x 9 in.; catalog on Leyner Oil Furnace No. 3. Form 9010, 4 pages, 6 x 9 in.; catalog on the "Sergeant" ticket-cancelling box. This ticket box is being used successfully in all places where great quantities of tickets must be disposed of without possibility of their ever being placed in circulation again. Form 9123, 24 pages, 6 x 9 in.; catalog on "Imperial" Tie Tamping Outfits. Profusely illustrated, showing application of the tie tamping outfit on many of the important railroads in the United States. Form 9026, 12 pages; catalog on Ingersoll-Rand High-Speed Piston Valve Steam Engine, Class "F." This engine is of the horizontal center-crank type, and the steam valve is of the most approved design, permitting the use of the highest steam pressures and superheated steam. Catalog contains cross-sectional illustrations showing the machine in detail. Form 9028; 18-page catalog on Ingersoll-Rand Equipment for Sugar Factory and Refinery Service. This catalog is offered in both English and Spanish editions. Copies of these catalogs can be had free on request to any of the Ingersoll-Rand Co. offices.

New Construction

PROPOSED WORK

Conn., New Haven—J. D. Kauffman, 17 Church St., will install a steam heating and vacuum cleaning system, refrigerating plant, etc., in the 8 story, 81 x 114 ft. apartment hotel which he plans to build on Orange and Bishop St. Total estimated cost, $300,000. J. Weinstein, 6 Church St., Arch.

Conn., New Haven—Pugliese & Miller, 70 Wright St., will install a steam heating plant, vacuum cleaning system, electric elevators, etc., in the 4 story, 100 x 101 ft. apartment hotel which they plan to build on Chapel St. and Boulevard. Total estimated cost, $175,000. Marchetti & Payne, 756 Main St., Hartford, Arch.

Conn., Waterbury—The Congregation of the Church of the Immaculate Conception will install a steam heating system in the church which it plans to build on East Main St. Total estimated cost, $100,000. Luke Fitzsimmons, 97 East Main St., Pastor. J. A. Jackson, 1133 Broadway, New York City, N. Y., Arch.

N. Y., Bath—The County Dairymen's League will install steam equipment and ammonia system in the dairy plant which it plans to build here. Total estimated cost, $150,000. M. W. Davison, Dir.

N. Y., Black River—The Northern New York Utilities, Inc., 58 Public Sq., Watertown, plans to construct a concrete power house on the Black River to accommodate 3 vertical 1000 kw. generating units; also build a power canal. J. B. Taylor, Pres.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., New York City, will install a steam heating system in the 5 story, 118 x 192 ft. school which it plans to build on Dumont Ave. between Wyona Ave. and Vermont St. Total estimated cost, $543,474. C. B. J. Snyder, Municipal Bldg., New York City, Arch. and Engr.

N. Y., Brooklyn—The Kings Highway Corporation, 1817 Kings Highway, will install a steam heating system in the 2 story, 104 x 120 ft. theater which it plans to build on Kings Highway and East 12th St. Total estimated cost, $175,000.

N. Y., Carthage—The Carthage Sulphite Pulp & Paper Co., Front St., plans to repair and build additions to its boiler house and install equipment in same. Address C. E. Eaton.

N. Y., New York—Baker, Carver & Morrell, 39 Water St., will install a steam heating system in the 9 story, 28 x 83 ft. office and loft building which they plan to build at 37 Water St. Severence & Van Allen, 4 West 37th St., Arch.

N. Y., New York—The Buick Auto Repair Shop, 244 West 49th St., will install a steam heating system in the 1 story, 100 x 200 ft. garage which it plans to build on 54th St. near 8th Ave. A steam heating system will be installed in same. Total estimated cost, $400,000. T. J. Bird, 101 Park Ave., Arch.

N. Y., New York—H. Claman, 241 West 43rd St., will install a steam heating system in the 10 story, 100 x 100 ft. hotel which he plans to build on 43rd St. near 8th Ave. Gronenberg & Leuchtag, 241 West 43rd St., Arch.

N. Y., Syracuse—The Onondaga County Orphans Home plans to install heating and drainage systems in the 10 cottages which it plans to build. B. J. Hotaling, Supt.

N. Y., Syracuse—The Onondaga Milk Producers Co-operative Association plans to build a milk condensary and would like to receive prices on boilers, condensers, handling devices, etc., which will be installed in same. Estimated cost, $150,000. Address C. L. Amos, 1204 James St.

N. Y., Watertown—The Northern New York Utilities, Inc., 58 Public Sq., plans addition to generating plant at Effley Falls. Project includes the construction of a 30 x 38 ft. power house to accommodate 1 vertical generator with governor, revamping dam, etc. J. B. Taylor, Pres.

N. Y., Watertown—The Northern New York Utilities, Inc., 58 Public Sq., plans to develop power on the Oswegatchie River at Browns Falls. Project includes the construction of a power house, dam, 3 vertical generating units, flume and tail race. Address J. B. Taylor.

Penn., Chester—The Foster Hotel Corporation is having plans prepared by E. Allen Wilson, Arch., 1208 Chester St., Philadelphia, for the construction of a 4 story, 118 x 228 ft. hotel at 9th and Welsh St. A steam heating system will be installed in same. Total estimated cost, $250,000.

Penn., Reading—W. I. Luden Co., 216 North 8th St., will install a heating plant consisting of a low pressure boiler, electric elevator and pipes with radiators in the 4 story 100 x 156 ft. mill building which it plans to build. Total estimated cost, $40,000. Address A. N. Bodey, Gen. Mgr.

Md., Cumberland—The Berwin White Coal Mining Co. plans to construct a power plant, which will furnish current to the company's 8 mines in Windber, near here. Estimated cost, $500,000.

Md., Baltimore—E. H. Joselyn, 701 North Durham St., will install a steam heating plant, boiler and engine for power in the 1 story 75 x 125 ft. addition which it plans to build to its candy factory. Total estimated cost, $15,000. Callis & Callis, 2055 Kennedy Ave., Arch.

Md., Cumberland—The Kelly Springfield Tire Co., Cook St., Akron, Ohio, plans to construct several additions to its plant to include a power plant and electric-light system. Total estimated cost, $2,000,000 to $2,500,000. H. B. Blanchard, c/o company, Engr.

Va., Norfolk—R. T. Lipscombe, 34 Virginia National Bank Bldg., and others, plans to build an ice, cold-storage and dehydration plant. Estimated cost, $225,000. B. Mitchell, Seaboard Bank Bldg., Arch.

Va., Alexandria—The Bureau of Supplies & Accounts, Navy Department, Washington, D. C., will soon award the contract for installing 2 exhausters and 2 constant duty motors at the Navy Yard here. Schedule No. 7817½.

N. C., Charlotte—The city will install steam heating and ventilating systems in the 3 story high school which it plans to build. Total estimated cost, $135,000. E. Sayward, Chamber of Commerce Bldg., Atlanta, Ga., Arch.

Fla., Winter Garden—The city plans election to vote on from $30,000 to $35,000 bonds to build complete water supply system, to consist of oil pumping engines, brick pumping station, etc. W. Ginn, Sanford, Engr.

Ala., Birmingham—The Birmingham Ry. Light & Power Co., 2001 1st Ave., plans to install a new water gas set. Estimated cost, $75,000. H. E. Cox, Ch. Engr.

La., Kaplan—The city plans to reconstruct the water-works and light plant. Estimated cost, $40,000. X. A. Kramer, Magnolia, Miss., Engr.

Ohio, Cleveland—The Ullman-Philpott Co., 4805 Lexington St., is in the market for various motors, ranging from 3 to 30 hp. in phases from 2 to 3, alternating current.

Ill., Chicago—Ascher Bros., 220 South State St., will install a steam heating system in the 1 story, 155 x 200 ft. moving picture theater which they plan to build on 92nd St. and Commercial Ave. Total estimated cost, $250,000. H. L. Newhouse, 4630 Prairie Ave., Arch.

Ill., Gillespie—The Board of Education will install a steam heating system in the 2 story, 140 x 154 ft. high school which it plans to build. Total estimated cost, $125,000. J. W. Kennedy, Cahokia Bldg., East St. Louis, Engr.

Ill., Watertown—The State Legislature plans to install an artificial ice machine having a daily capacity of 10 tons, at the Watertown Hospital for Insane.

Kan., Lyons—The City Council plans to extend the waterworks system; will also install pumps for 2 new wells.

N. D., Dickinson—The Budget Committee, Capitol, Bismarck, plans to build a heating plant at the State Normal School here. Estimated cost, $35,000.

Mo., Macon—W. H. Martin, City Clk., will receive bids until March 20 for improving power plant. Estimated cost, $45,000. F. L. Wilcox, Syndicate Trust Bldg., St. Louis, Engr. Noted Feb. 4.

Mo., St. James—The Missouri State Soldiers' Home plans to install new power house equipment at the home here. Estimated cost, $7,600. W. V. Farris, Pres. Bd. Mgrs.

Mo., St. Joseph—The city plans an election soon to vote on bond issue for improving the lighting plant. Hale Judson, City Engr.

Colo., Denver—The Jackson Compressor Co., 235 South Cherokee St., will soon receive bids for the construction of a 1-story electric furnace plant. Estimated cost, $225,000.

Colo., Sterling—The city voted in favor of a $16,000 bond issue for building a transmission line from Sterling to Tecumseh.

Ore., Astoria—The Pacific Power & Light Co., Spalding Bldg., Portland, plans to build a 1500 hp. electric generating plant at the foot of Astor St. J. B. Kilmore, Dist. Mgr.

Cal., Elsinore—G. I. Lamy, Engr., Marsh-Strong Bldg., Los Angeles, has applied to the State Water Commission for permission to appropriate 120 second feet of waters of Lake Elsinore to irrigate 20,000 acres of land. Plans include the construction of power and pumping plant, etc. Total estimated cost, $1,000,000.

Cal., Hanford—The California Packing Co., 101 California St., San Francisco, plans to construct a power house in connection with the 1 story 110 x 250 ft. fruit packing plant which it will build. P. Bush, 101 California St., San Francisco, Engr.

Cal., Long Beach—The city has authorized W. T. Lisenby, Mayor, to investigate the feasibility of building an electric light plant and purchasing distributing system owned by the Southern California Edison Co., Los Angeles. D. S. Miller, City Engr.

Cal., Mare Island (Vallejo P. O.)—The Bureau of Supplies & Accounts, Navy Department, Washington, D. C., will soon award the contract for installing motor generator set at the Navy Yard here; Schedule No. 7815½.

Cal., Mare Island (Vallejo P. O.)—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install motor and blading for turbo-alternators in Navy Yard, here. Estimated cost, $7500.

Cal., Merced—The Merced Union High School Dist. plans to build a power house, administration and assembly building, etc. in connection with the group of high school buildings which it plans to construct. Estimated cost, $130,000. Allison & Allison, 1405 Hibernian Bldg., Los Angeles, Arch.

Que., Ste. Agathe—A. Gagnon, Secy. Department of Public Work and Labor, Quebec, will receive bids until March 14 for the construction of power house, heating and plumbing, electric wiring, etc., at the Laurentian Sanatorium here.

Ont., Bowmanville—The Polusterine Products Co., 170 Ontario St., will move its plant from Toronto to Bowmanville, and is in the market for a 25 hp. steam boiler, 2½ hp. electric motor, 150 gallon steam kettle, etc. H. V. Hohs, 170 Ontario St., Toronto, Mgr.

Ont., Orillia—The Department of Public Works, Toronto, will receive bids until March 31 for the construction of a 5 story power house and hospital on Main St. Estimated cost, $40,000 and $25,000 respectively.

Ont., Ottawa—The Board of Control has been authorized to have plans prepared and submit report on the advisability of establishing central heating plant on Albert St. for city hall, police station No. 8, fire hall and registry office. Estimated cost, $80,000. A. F. McCallum, City Hall, Engr.

CONTRACTS AWARDED

N. Y., Utica—The State Hospital Commission, Capitol, Albany, has awarded the following contracts for work at the Utica State Hospital: constructing additional central heating plant, to R. G. Lloyd, 113 South St., cost, $29,832; installing new boilers, to McNaul Boilers Co., 983 Front St., Toledo, Ohio, $58,130; heating work, piping, etc., to W. B. Armstrong Co., Fulton St., Albany, $39,640. Noted Feb. 25.

N. Y., Wards Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing refrigerating plant equipment at the Naval Hospital Reservation here, to Frick Co., Inc., West Main St., Waynesboro, Penn. Estimated cost, $21,074 (93 days). Noted Feb. 18.

Penn., Philadelphia—The L. W. Hirsch Co., 923 Market St., has awarded the contract for the construction of a 5 story, 40 x 200 ft. department store at 925-27 Market St. to Melody & Keating, 1322 Race St. A steam heating system will be installed in same.

N. D., Jamestown—The Bridgeman-Russell Co. has awarded the contract for the construction of a 2 story, 30 x 60 ft. addition to its steam generator and condensing plant, to the Northern Construction Co., Grand Forks.

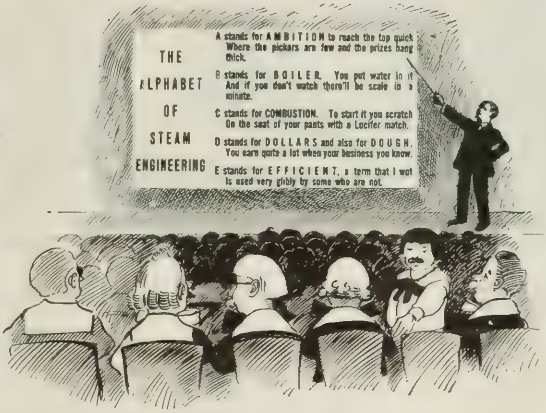
Ore., Astoria—The Astoria Flouring Mills Co. has awarded the contract for installing an 800 hp. electric motor, 48 stand rolls and 16 shifters in its new mill to the Nordyke Marmon Machine Co., 250 North Meridan St., Indianapolis, Ind.

POWER

Volume 49 New York, March 18, 1919 *Number* 11

The Alphabet of Steam Engineering

By JOS. W. HAYS


THE
ALPHABET
OF
STEAM
ENGINEERING
A stands for AMBITION to reach the top quick
Where the pickers are few and the prizes hang thick.
B stands for BOILER. You put water in it
And if you don't watch there'll be scale in a minute.
C stands for COMBUSTION. To start it you scratch
On the seat of your pants with a Lucifer match.
D stands for DOLLARS and also for DOUGH.
You earn quite a lot when your business you know.
E stands for EFFICIENT, a term that I wot
Is used very glibly by some who are not.

A stands for AMBITION to reach the top quick,
Where the pickers are few and the prizes hang thick.

B stands for BOILER. You put water in it
And if you don't watch there'll be scale in a minute.

C stands for COMBUSTION. To start it you scratch
On the seat of your pants with a Lucifer match.

D stands for DOLLARS and also for DOUGH.
You earn quite a lot when your business you know.

E stands for EFFICIENT, a term that I wot
Is used very glibly by some who are not.

F stands for FURNACE and FIREMAN, too;
When they both tend to business the coal man looks blue.

G stands for GASES that go up the flue.
Look out or you'll waste a heat unit or two.

H stands for the HOLES that let air through the fire.
You must watch for such air holes; with waste they conspire.

I stands for INTENTION to stop up the leaks;
You can do it today. Why defer it for weeks?

J stands for the JOY that the manager fills.
When the month's balance sheet shows some small fuel bills.

K stands for the KNOWLEDGE that some engineers
Acquire quite quickly while others take years.

L stands for the LIGHTS that in dark corners gleam
When the chief engineer knows the cost of the steam.

M stands for the MOMENT to stop fuel waste;
The moment is Now and the password is Haste.

N stands for the NOTION at one time supreme
That the plant was all right when it made enough steam.

O stands for OXYGEN; wide is its use.
"Oxy" means "acid" and "gen" means "produce."

P stands for POWER. It comes from a press,
And sometimes from a Corliss or turbine, I guess.

Q stands for the thing that they call QUESTIONNAIRE.
You fill out the blanks and you put up a prayer.

R stands for REPAIRS which you ought in all reason
Get out of the way in the slack summer season.

S stands for the STEAM you waste coal to produce
And you waste the same steam when you put it to use.

T stands for TURBINE. Our friend Jamie Watt
Would gasp could he see us shoot steam through a pot.

U stands for UPTAKE. For a sample of gas
For your Orsat, avoid it and use the last pass.

V stands for the thing that we often call VIM.
Without it you sink. When you have it you swim.

W stands for WATER. In one more short year
We'll all have to drink it and play it is beer.

X stands for XPERT and XPERIENCE too.
When you've gathered the second the first becomes you.

Y stands for the jaw-breaker YOUGHIOGHENY,
A coal and a town out in West Pennsylvany.

Z stands for ZEST for the work we are in
And with Zest comes Success. NOW LET'S GO IN AND WIN!

Bureau of Mines' New Laboratories

An unusually well-illustrated article describing the new laboratories of the Bureau of Mines, and telling of the plans of the Fuel Section of the Bureau.

IT MAKES one feel good to get new tools with which to work. So there will be rejoicing in the fuel-mining and fuel-using industries to know that Uncle Sam has just completed for them a workshop, the finest of its kind to be found anywhere. And this workshop, with its corps of engineers and chemists, reaches out to the most remote power plant, oil well and refinery, to the farthest mine and to the most isolated coal and oil consumer.

Almost everyone knows Carnegie "Tech" and its imposing location atop the hills that look down into the valleys from which rises the smoke of the great mills that have made Pittsburgh an industrial colossus. The new laboratories of the Bureau adjoin "Tech," fronting on Forbes Street some several hundred feet up from the Carnegie Museum, forming a part of that famous civic center in which are located the University of Pittsburgh, Mellon Institute of Industrial Research, the Athletic Club, Masonic Temple and other beautiful structures. While the material and architecture of the laboratories were made to harmonize with "Tech," the buildings, as well as their layout, remind one of the Wentworth Institute, Boston.

The buildings are laid U-shape, the administration building connecting two wings, the right mechanical, the left chemical. The outside, over-all dimensions are: Total front on Forbes Street, 332 ft.; total depth each wing, 211 ft.; width each wing, 46 ft. The mechanical laboratory is 46 x 211 ft. The fuel laboratory is 51 x 65 ft. with 26-in. ceiling. Back of and with their roofs on a level with ground floor of the laboratories, are the power plant and the fuel-testing laboratory, where Henry Kreisinger and his associates will conduct their experiments, in which *Power* readers are so vitally interested. This fuel-testing laboratory is of concrete construction, like the power plant, and is large enough to accommodate much apparatus. The walls are about 70 per cent. glass, giving excellent light conditions. Later, as the work of the laboratories increases, the fuel wing will extend out over railroad tracks already laid, and eventually the buildings will bridge the great ravine that now separates the laboratories from the Carnegie Institute of Technology.

The first floor of the chemical wing is occupied by the petroleum laboratory and the coal-sampling plant. In the latter samples of coal are prepared for analyses, and from 300 to 400 such analyses are made per month. The coal sample, as it comes from the mine or the car, is crushed to 10-mesh in a roller mill, then air-dried, after which it is ground to 60-mesh in a ball mill; most of this 60-mesh sample will pass through a 100-mesh screen. The coal is now ready to be sent upstairs for analysis, the containers being 4-oz. bottles, each carrying 40 grams of the coal. All analyses are recorded on cards which are kept on file by the Service Department of the Laboratories. For making coal analyses a calorimeter of the Parr type, modified and designed by the Bureau, is used. The coal sample coming in for analysis bears a number which is in one column of an indicating board, the other columns each representing one of the subjects for determination; that is, moisture, sulphur, ash, volatile, fixed carbon and heating value. A fresh sample to be analyzed has its number, and in each of the columns mentioned a brass brad is stuck; this is removed when the determination which it represents is made. A glance at the board therefore indicates the progress of the analysis.

Of course the Bureau uses a great variety of instruments, gages, etc., some of which are special and designed and made by the Bureau. To do this work there is a corps of instrument makers, and a well-fitted machine shop for them is maintained. The shop is shown on page 386. Instruments, gages, meters, thermometers, etc., used by the Bureau are calibrated in a room fitted for the purpose and located on the second floor.

Now all gas-analysis work is under one head and is done in one room exceptionally well fitted for the work. Mine-gas samples are collected in thin glass bottles, evacuated of air and sealed. To collect a sample one locates the bottle where one wishes, breaks off the small glass tip, allowing the gas to rush into the air-evacuated bottle. When the sample is collected, the opening is sealed with wax. Samples of flue and other gases are drawn over mercury. Men from this laboratory are trained to make as high as forty flue-gas analyses an hour.

The Mining Division, with its special laboratories, its rescue work apparatus, etc., is especially interesting, but space permits description only of that which concerns the power-plant man.

During the war, owing to urgent war work, many of the rooms were used for purposes other than originally intended. This has caused some laboratories to temporarily occupy other rooms.

The laboratory where investigations in combustion of fuels and in steam-boiler performance are to be made has not been fully fitted up as yet owing to the press of urgent war work upon Mr. Kreisinger, the engineer conducting such researches. But *Power* readers, and all industrial consumers of fuel, in fact, will be pleased to know that a praiseworthy program upon which work will soon begin, has been laid out for this laboratory.

This department has thoroughly treated of hand-firing and low rate combustion, particularly in horizontal-tubular boilers. One of the first items on the new program will be investigations into combustion on underfeed multiple-retort stokers. Power-plant men will look with interest for the results of this work, despite the fact that considerable study has already been given the subject by public-service corporations, stoker manufacturers and individual engineers.

The Bureau will soon begin studies in connection with the present use of powdered coal for power plants and metallurgical purposes. Of course powdered coal for boiler furnaces is not new, but it is true that nearly all those conducting tests and publishing results have been enthusiasts. The Bureau will have the advantage of beginning its work without prejudices or preconceived opinions.

Further studies are to be made of heat transmission in boilers. The metallurgical industry, particularly, is interested in the combustion of various cokes, and this will be investigated. Design of furnaces for house-heating boilers is another item on the program. The foregoing work will be done for the most part in the fuel-testing laboratory.

Of importance is the subject of the partial distillation of bituminous coal, taking out the volatile for the valuable hydrocarbon products, using the residue for fuel. This process leaves the coal or residue with about 75 per cent. of its original heating value. The new laboratories likely will be the scene of investigations in this highly portentous field. The Bureau also will at its earliest convenience attempt determinations of the specific heat of the various gases in flue gas. There follow the plans of the Fuel Section of the Bureau:

OUTLINE OF WORK IN FUEL SECTION

STEAM BOILERS AND FURNACES

Field Work:

1. Coöperation with Emergency Fleet Corporation; baffling of marine boilers; design of marine boiler furnaces and study of combustion in same. Study of insulating materials used in furnace walls.
2. Study of lignites as fuel for steaming purposes.
3. Storage of coal.

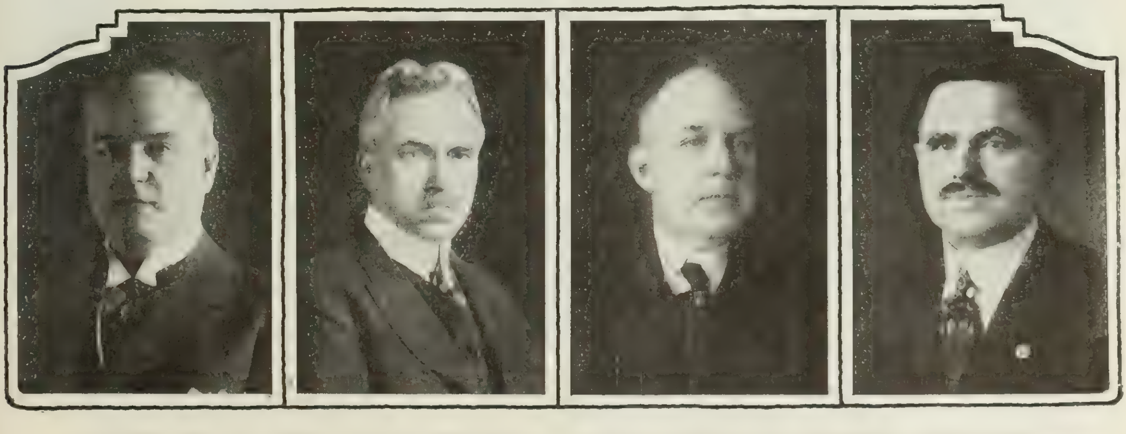
Laboratory Work:

1. Study of the draft required for burning at various rates, different kinds of coal and different mixtures of sizes.
2. Study of the effect of melting point and the composition of ashes on the clinker trouble in boiler furnaces.
3. Study of the use of lignites for house heating.
4. Study of the combustibility of carbon in different forms—coke, soot, anthracite, etc.
5. Study of heat transmission in steam boilers.
6. Effect of scales on the heat transmission in steam boilers.

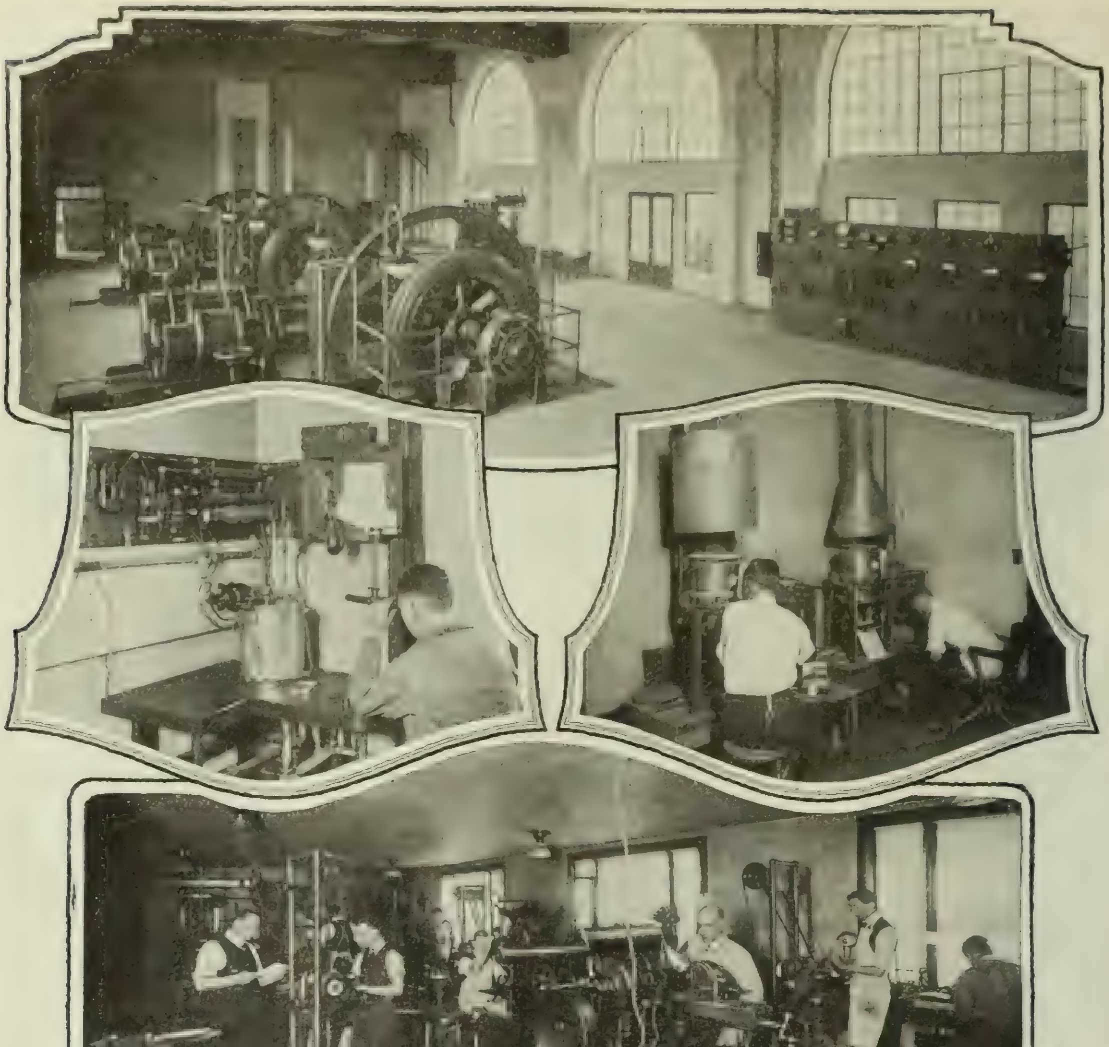
POWDERED COAL

Field Work:

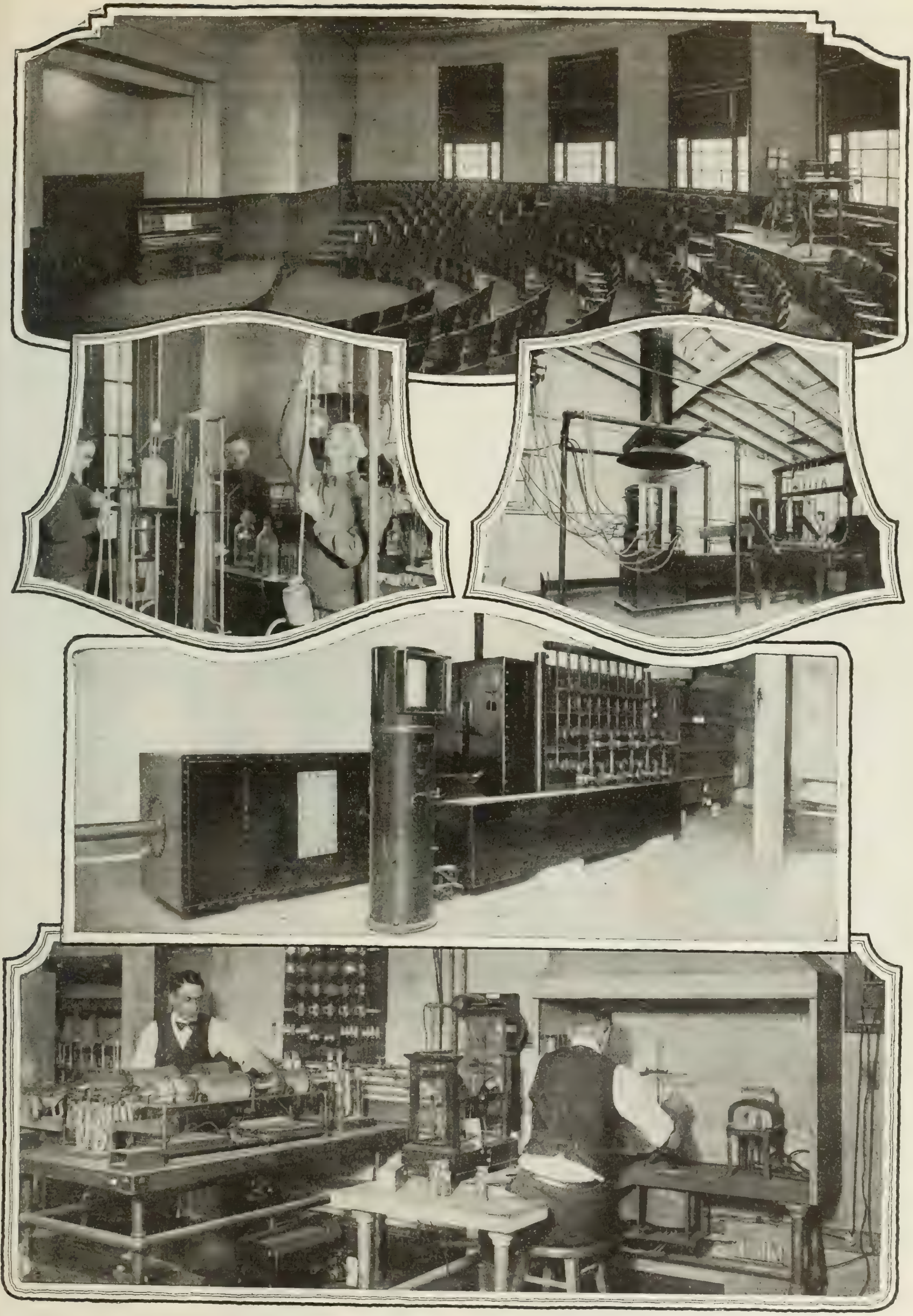
1. General survey of the use of powdered coal for steam and industrial purposes.
2. Coöperation with some firm to help develop the use of powdered coal for steam and other purposes.
3. Investigation of the durability of furnace lining in powdered-coal furnaces.
4. Storage of powdered coal.



FROM LEFT TO RIGHT: VAN H. MANNING, O. P. HOOD, DORSEY A. LYON, HENRY KREISINGER



ENGINE ROOM, COAL CALORIMETER TESTING, ASH-FUSION TESTS, MACHINE SHOP, REAR VIEW OF LABORATORIES



AUDITORIUM, GAS ANALYSIS, FUEL-TESTING FURNACE, DRYING OVENS, VIEW IN COAL-TESTING LABORATORY

Laboratory Work:

1. Study of the composition and the fusibility of ash as affecting the removal of ash from industrial and boiler furnaces.
2. Study of suitable refractory material for lining furnaces, to resist the slagging action of ash from different coals.

FUEL IN METALLURGICAL FURNACES

Field Work:

1. Study of the design and economic operation of metallurgical furnaces.
2. Study of probable application of mechanical stokers to metallurgical furnaces.

Laboratory Work:

1. Study of the combustibility of different cokes in contact with oxygen and CO. (This work to be done in coöperation with the Metallurgical Section.)

BYPRODUCT PLANT

Field Work:

1. General survey of the byproduct-plant industry and of the possible lines of development in near future.
2. Coöperation with some industrial plant in solving certain phases of the byproduct industry on commercial scale.

Laboratory Work:

1. Examination of tars and oils, and developing new methods for determining the actual compounds, the action of these under heat treatment, and the conditions favorable and unfavorable for their production. Study of possible new products and new uses.
2. Study of relative value of coke for blast furnaces and other uses. This is the same problem as mentioned in "Fuel in Metallurgical Furnaces, Laboratory Work (1)."
3. Study of expanding property of coal during coking.
4. Study of coals of the country with relation to coking properties.

USE OF FUEL IN CERAMIC INDUSTRY

1. Fuel economy and to produce better product.

On the second floor of the administration building are the offices of the mechanical engineers. It is here that data from tests and researches are worked up into form for publication in the bulletins of the Bureau.

The top floor of the administration building is given over to the technical-service department of the Bureau. Here photographs, drawings, prints, filing of important data, etc., are done for the various laboratories. It is as well fitted a place as the writer has seen in his many travels.

Among the many views of the laboratories and apparatus given in this article, is one of the engine room, showing the Nordberg engines. The boiler room, containing two 500-hp. Babcock & Wilcox boilers with Playford stokers, is temporary. Later, as the laboratories grow, it will be permanently located back of and parallel with the engine room.

Acknowledgment is due to Dorsey A. Lyon, supervisor of stations, Henry Kreisinger, engineer, and R. A. Wood, in charge of the service department, for their coöperation in the preparation of this article.

Blackburn-Smith Inclosed Tank Switch

The human element is not always dependable as is well known, and this is especially true in regard to controlling pumps used for filling roof tanks, etc., which are frequently forgotten, with the consequence that the tank overflows before the attendant remembers to shut down the pump.

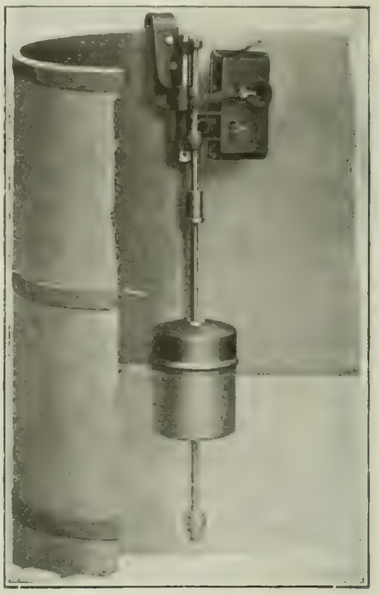
Various kinds of automatic switches have been devised for controlling the starting and stopping of motor-driven tank pumps, among them being the Blackburn-Smith inclosed tank switch, made by the Blackburn-Smith Corp., 105 West 40th St., New York City.

This switch is of the single-pole double-break type, is instantaneous in action and is suitable for use with tanks, etc., wherever regulation of liquid level between high and low limits is required. This regulation is obtained by a float operating the switch, which in turn actuates a solenoid controlling mechanical or other electrical devices.

The joint of the case is flanged to permit the use of a gasket when desired for waterproofing, and the internal electrical and mechanical parts are separated by an inside dividing partition which forms two separate compartments.

The fixed contacts are short cylinders of carbon, the moving contact is a folded copper strip and a flat spring keeps the contact piece always in correct position.

The operation is as follows: As the float riding up and down on a guide rod hits a limiting stop on the rod, the rod is carried up or down, and through collars upon its upper end imparts a corresponding movement to the switch lever. The movement of the lever oscillates a shaft and "grasshopper" levers, which in turn move a roller across a cam on the end of the electrical-contact lever. The roller is held closely to the cam by a coil spring fastened to the dividing partition in the case. The tension from this spring throws the contact lever with a quick positive motion the instant the roller passes over the center of the cam. This switch is furnished alone or with auxiliaries for mounting either on the cover of or to the wall of a tank.



INCLOSED TANK SWITCH

Advantage should be taken so far as possible of low-load periods to reduce the peak-load difficulties of the plant. For instance, boilers should be blown at noon hour or other times of light load, and this is the time to fill water tanks, charge storage batteries, blow tubes, run ash and coal conveyors, etc.

Refrigeration-Plant Log Sheets

The Committee on Uniform Log Sheets of the National Association of Practical Refrigerating Engineers has drawn up the forms shown. Above: Daily Report Sheet. Below: Monthly Report Sheet

Plant ____________ Date ________ 19 ______

TIME	STEAM PRESSURE	CONDENSER PRESSURE			TEMPERATURE OF DISCHARGE GAS			RETURN PRESSURE			TEMPERATURE RETURN VAPOR			R. P. M			WATER TEMPERATURE											BRINE TEMP.		TEMPERATURE FREEZING TANK			TEMPERATURE ROOMS						TEMPERATURE ICE STORAGE	VACUUM GAGE	DRAFT GAGE	OUTSIDE TEMPERATURE	FUEL USED	CO_2
		MACHINE No.			MACHINE No.			MACHINE No.			MACHINE No.			MACHINE No.			TO HEATER	TO BOILER	TO COOLING TOWER	FROM COOLING TOWER	TO CONDENSER	FROM CONDENSER	SUPPLY	FROM ABSORBER	FROM RECTIFIER	TO PRECOOLER	TO CANS	TO STORAGE	FROM STORAGE	TANK No.			ROOM No.											
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3														1	2	3	1	2	3	4	5	6						
7 A.M.																																												
10 A.M.																																												
1 P.M.																																												
4 P.M.																																												
7 P.M.																																												
10 P.M.																																												
1 A.M																																												
4 A.M.																																												
AV.																																												

MACHINE NO	START	STOP	START	STOP	TOTAL	METER READINGS 7 A.M		ENGINEERS	MATERIAL RECEIVED	MATERIAL USED
						OIL				
1						GAS				
2						WATT		FIREMEN		
3						WATER				
TOTAL No. BLOCKS PULLED, DAY						BRINE				
" " " " NIGHT						TONS OF COAL USED		TANKMAN		
" " " IN ICE HOUSE						CARS SHIPPED				
" " " IN DUMP ROOM										
TOTAL TONS PULLED								VAULTMEN	REMARKS (SHUT DOWNS, ACCIDENTS ETC)	
TOTAL TONS ON HAND, 7 A.M.										
QUALITY OF ICE										
								EXTRA LABOR		
								CHIEF ENGINEER		Signed

Plant ____________ Month ____________ 19 ______

DATE OF MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total	Average
HRS OPERATED. MACHINE No 1																																	
R.P M																																	
RETURN TEMPERATURE																																	
DISCHARGE "																																	
HRS OPERATED MACHINE No 2																																	
R.P M																																	
RETURN TEMPERATURE																																	
DISCHARGE "																																	
HRS. OPERATED MACHINE No 3																																	
R P M.																																	
RETURN TEMPERATURE																																	
DISCHARGE																																	
STEAM PRESSURE																																	
RETURN "																																	
DISCHARGE "																																	
VACUUM																																	
DRAFT																																	
OUTSIDE TEMPERATURE																																	
TEMPERATURE TANK No. 1																																	
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" SUPPLY WATER																																	
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" " FROM																																	
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" " " RECTIFIER																																	
" DIS. " TO FORECOOLER																																	
" " " " CANS																																	
" FEED WATER																																	
" FLUE GAS																																	
" ICE STORAGE No. 1																																	
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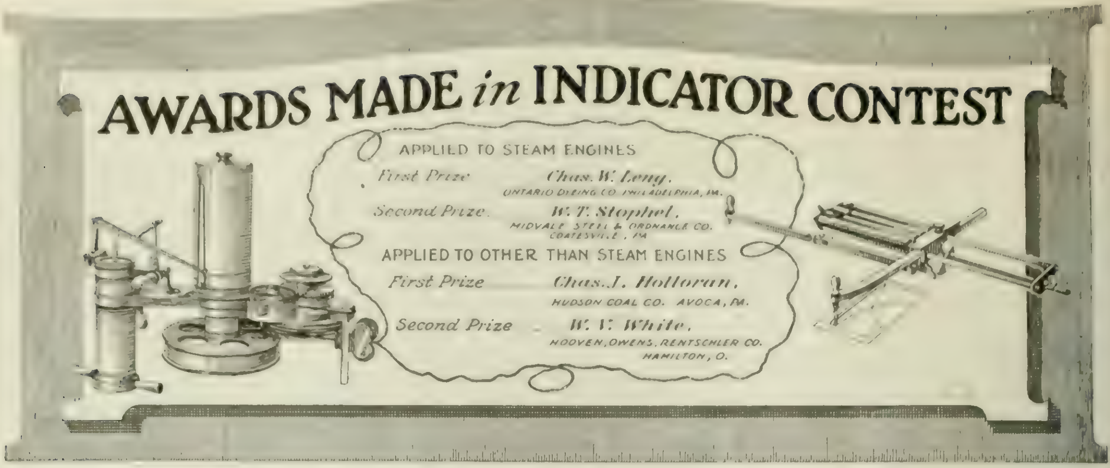
TOTAL No. OF BLOCKS PULLED TANK No 1																																	
" " " " No 2																																	
" " " " No 3																																	
"																																	
" " ON HAND 7 A M.																																	
TONS OF COAL USED																																	
FUEL OIL OR GAS METER READING																																	
WATTMETER READING																																	
WATER SUPPLY METER READING																																	
BRINE																																	
TEMP BRINE TO STORAGE																																	
" " FROM																																	

REMARKS		MATERIAL		No OF MEN EMPLOYED MFG.	EXTRA LABOR	KIND OF WORK
	RECEIVED	USED	ON HAND	ENGINEERS		
				FIREMEN		
				OILERS		
				TANKMAN		
				VAULTMAN		
					Signed	



AWARDS MADE *in* INDICATOR CONTEST

APPLIED TO STEAM ENGINES

First Prize — *Chas. W. Leng.* ONTARIO DYEING CO PHILADELPHIA, PA.

Second Prize. — *W. T. Stophel.* MIDVALE STEEL & ORDNANCE CO. COATESVILLE, PA

APPLIED TO OTHER THAN STEAM ENGINES

First Prize — *Chas. J. Holloran.* HUDSON COAL CO. AVOCA, PA.

Second Prize — *W. V. White.* HOOVEN, OWENS, RENTSCHLER CO. HAMILTON, O.

WITH a view to stimulating interest in effecting economies through proper valve settings of engines and other reciprocating apparatus, the Trill Indicator Co. some months ago offered through *Power* to award an indicator to the one reporting the most meritorious use of such instrument on a steam engine and another to the best report of its use on other than a steam engine. Second prizes consisting of planimeters were offered in each case.

At the time, in announcing the contest, it will be recalled that *Power* secured the consent of three prominent engineers to act as judges. These were Charles T. Main, then president of the American Society of Mechanical Engineers; David Moffat Myers, advisory engineer to the United States Fuel Administration; and George H. Barrus, then chairman of the Power Test Committee of the American Society of Mechanical Engineers.

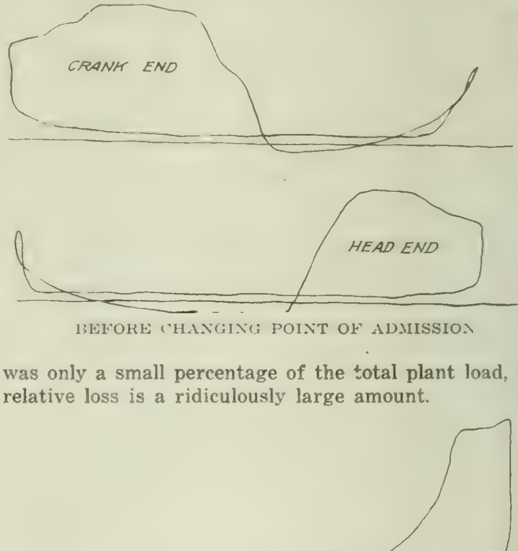
The contest closed on Nov. 30, 1918. After going through the numerous papers submitted, the judges have arrived at an almost unanimous decision, which is as announced above. The four successful papers are reproduced herewith.

CHARLES W. LENG

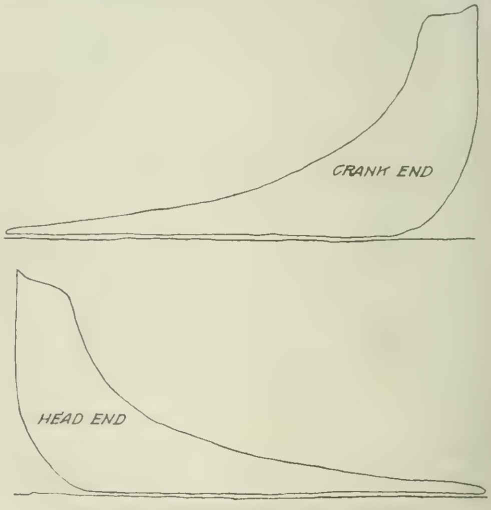
THE four diagrams were taken from a 9 x 14-in. Salem Buckeye engine at the Harrison Bros., Gray's Ferry Chemical Works, Philadelphia, Nov. 7 and 9, 1893, at which time the writer was employed at this plant as assistant engineer. The engine mentioned, known as No. 38 electric light engine, was one of fifty-four engines of various types and sizes ranging from 20 x 42-in. Green to small Westinghouse Juniors, which accounts for the fact that it ran in the condition shown in the first two diagrams without its extravagance being noticed, it being only a small portion of the total load.

Among the first duties assigned the writer was the indicating of the various engines, which resulted in the production of the most valuable curios in his collection.

This is the only case that has come to the notice of the writer in which regulation was effected by varying the point of admission instead of cutoff, and while the actual saving by correcting the defective valve action was only a small percentage of the total plant load, the relative loss is a ridiculously large amount.



BEFORE CHANGING POINT OF ADMISSION



AFTER CHANGING POINT OF ADMISSION

Investigation brought out the information that the engine had, prior to its application to the lighting load, been run in the opposite direction and when reversed, the main eccentric only was adjusted for the new direction without reversing the governor action.

In a plant in which this was the only engine used, this condition would probably have been discovered without the indicator, but the fact that the engine ran smoothly and with acceptable regulation on a lighting load for a considerable period, would indicate that this condition might have prevailed indefinitely had it not been for the application of the indicator.

Philadelphia, Penn. **Charles W. Leng.**

W. T. STOPHEL

THERE are submitted herewith indicator diagrams taken from a 12 x 18-in. engine driving a Mesta plate and scrap shear. The engine is of piston-valve type. The diagram marked "as found" shows the very poor setting of the valves. With this setting it was difficult to start the engine at all, and at times the flywheel would have to be turned by hand and the steam then turned on before the engine would start. Besides the valve being far out of position, there was, and is still, considerable lost motion in the valve rod.

The card marked "final" shows a marked improvement over the original setting. The results as calculated from the cards are as follows:

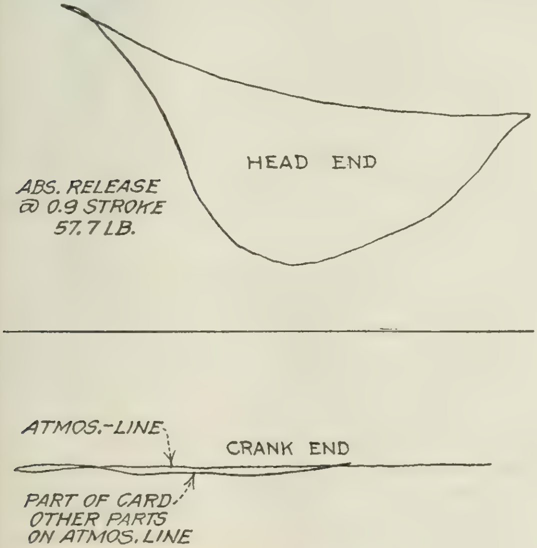
"AS FOUND"

Horsepower = 6.9
Steam per hp.-hr = 93.2 lb. (dry)
Steam per hp.hr. = 121.2 lb. (wet)
Total per hour = 836.0 lb. (wet)

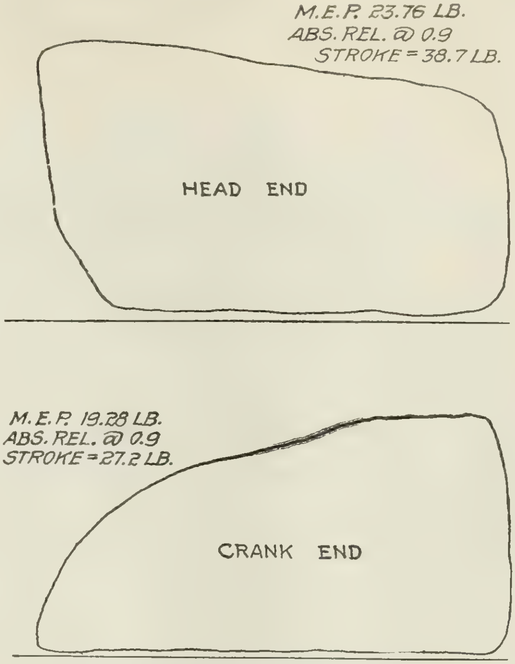
"FINAL"

Horsepower = 16.3
Steam per hp.-hr. = 45.7 lb. (dry)
Steam per hp.-hr. = 59.4 lb. (wet)
Total per hour = 968.0 lb. (wet)

From these results the great advantages of using an indicator can easily be seen, as in this case the water rate is lowered 51 per cent. and they are now able to start the shear without any trouble and are also getting much more power to do the work required.



DIAGRAMS SHOWING VALVE SETTING "AS FOUND"



DIAGRAMS SHOWING "FINAL" SETTING

The diagrams were taken with a Trill continuous-type indicator. **W. T. Stophel.**

Coatesville, Penn.

CHAS. J. HOLLORAN

THE attached diagrams were taken from a 16 and 25 x 25 and 16 x 24-in. cross-compound two-stage steam-driven air compressor. Diagram No. 1 was taken from the 25-in. intake cylinder and shows an m.e.p. of 22 lb. as traced by indicator. The dotted lines show the plotted adiabatic curve, the crank end showing an m.e.p. of 19.75 lb., and the head end 19 pounds. Diagram No. 2 was taken from the same cylinder after renewing the poppet discharge valves, on both head and crank ends. The crank-end m.e.p. was 18 lb. and the head-end 19 lb.

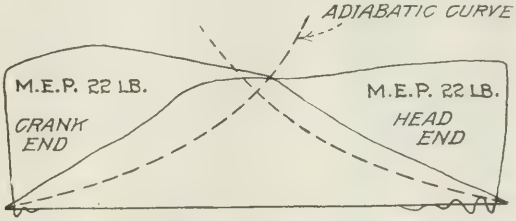


DIAGRAM NO. 1. FROM INTAKE CYLINDER BEFORE RENEWING POPPETS

Diagram No. 3 was taken from the high-pressure or second-stage cylinder. The head end shows an m.e.p of 89 lb. as traced by the indicator. After plotting the adiabatic curve, the same end shows an m.e.p. of 66 lb. The crank end as traced by indicator shows an m.e.p. of 67 lb. No. 4 was taken from the same cylinder after renewing the poppet valves with the result that the crank-end m.e.p. was 57 lb. and the head-end 58 pounds. CHARLES J. HOLLORAN.

Avoca, Penn.

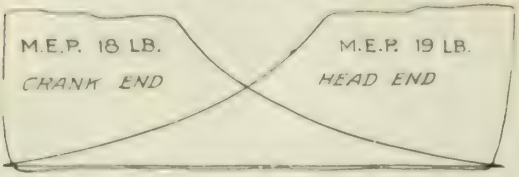


DIAGRAM NO. 2. FROM INTAKE CYLINDER AFTER RENEWING POPPETS

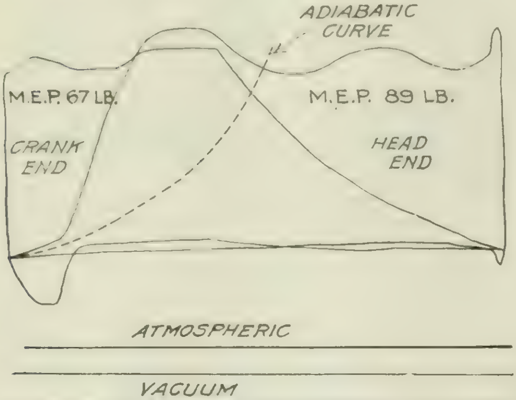


DIAGRAM NO. 3. FROM HIGH-PRESSURE CYLINDER BEFORE RENEWING POPPETS

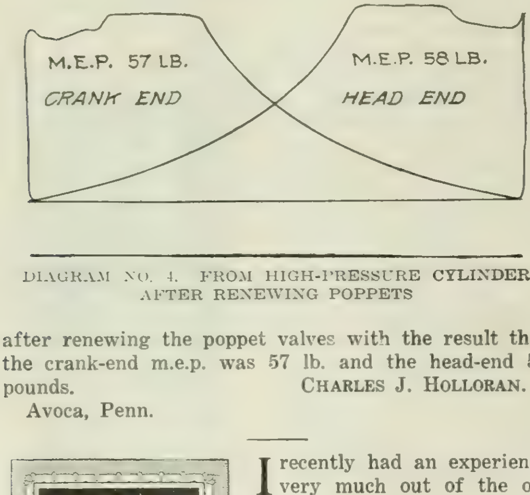
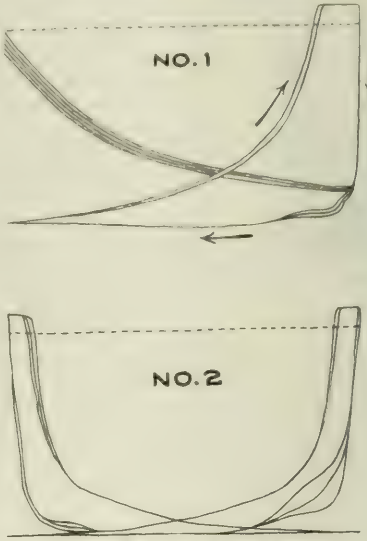


DIAGRAM NO. 4. FROM HIGH-PRESSURE CYLINDER AFTER RENEWING POPPETS

W. V. WHITE

I recently had an experience very much out of the ordinary, in the case of an air pump working on a surface condenser and in my charge as erector for the builders of a municipal pumping engine, built by the Hooven, Owens, Rentschler Co. The air pump was a "Blake," with water cylinder 12 x 12 in., which had a bad "kick" on one end—would do nothing whatever on one end. Two experts came from the makers to examine it. The first wanted different springs put in, which was done, but without results; the second wanted new valves put in, but they did no good. I then put on the indicator and got diagram No. 1. This diagram would be considerable of a puzzle to many operators, but is readily understood when explained. The right-hand end is a fine "air-compressor" diagram (which, in fact, an air pump really is). The valve opening is good and the intake as well, while the compression is ideal and the delivery fine.

The left-hand end is the "sticker"—it has nothing to show but a compression line. The intake runs back on the compression and does not rise high enough to discharge, neither does the intake come to correspond to the suction due to that produced by the other end.



DIAGRAMS TAKEN BEFORE AND AFTER CUTTING HOLES IN DISCHARGE VALVES

The answer to it all is excessive clearance on that end. The pump was handling only some 1800 lb. of water per hour, which was not enough to take up the clearance on both ends, so the smaller clearance took the supply and did the work and allowed the other end to "kick."

Acting on this analysis, some holes were cut in the discharge valves on that end, allowing enough water to leak back to fill the clearance; then diagram No. 2 was taken. W. V. WHITE.

Hamilton, Ohio.

Paint To Reduce Power-House Accidents

Camouflage was developed to reduce visibility in the war. The reverse of the same principle has been adopted in the plant of the Union Gas and Electric Co., Cincinnati, Ohio, to reduce accidents. In one conduit gallery in the plant where the ceiling is low, a number of angle irons project down to levels at which a man's head is likely to collide with them if he is careless. To make these irons easier to see so that such accidents will be less likely to occur, the company has painted the projecting struts with alternate bands of black and white about three inches wide.

Don't think, because the war is over, that the bills don't have to be paid!

Reconnecting Induction Motors—General Summary

By A. M. DUDLEY
Designing Engineer, Westinghouse Electric and Manufacturing Company

During the last two years a series of thirteen articles have appeared in "Power" on the subject of reconnecting induction motors. It is the purpose of this article to sum up the principles brought out in the series and to give an outline of the practical points that must be considered in deciding whether or not a given motor may be reconnected for different conditions without new coils or core iron.

THE main principles which operate to fix the limits of the different combinations, such as series, parallel, series star, parallel star, series delta, parallel delta, etc., possible with a single winding, may be enumerated somewhat in the following manner:

1. The mechanical output of a motor is limited by the cross-section of copper available to carry current and by the cross-section of iron available to carry magnetic flux.

2. An induction motor is also at all times an alternating-current generator as well, and the voltage generated by its own rotating field cutting the conductors of its own stator coils must at all times very closely approximate the applied line voltage.

3. It is necessary that the pitch or throw of the coils bear some reasonable physical relation to the number of poles that the machine has. For example, in a 4-pole motor the coils should throw somewhere near ¼ of the circumference of the stator bore, in a 6-pole motor somewhere near ⅙ the circumference, and so on. The practical limits to the throw are from ½ to 1½ times this full-pitch value. That is to say, in a 72-slot 6-pole motor the full or exact pitch for the coil throw would be $\frac{72}{6} = 12$ slots, or the coil would be in slots 1 and 13. Using the limits ½ to 1½ as given, the throw of the coil should be not less than 6 slots nor more than 18 slots for possible operation; that is, the coils should not spread less than slots 1 and 7 nor more than slots 1 and 19.

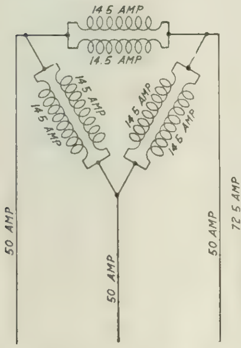


FIG. 1. TWO-PARALLEL DELTA CONNECTION

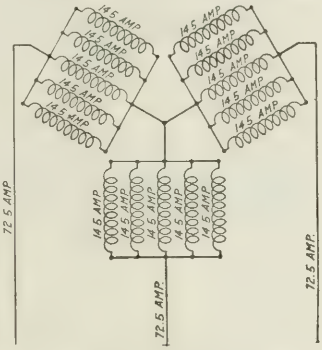


FIG. 2. FIVE-PARALLEL STAR CONNECTION

4. All changes in operating conditions whether of horsepower, voltage, phases, frequency or poles, may be reduced to terms of change in voltage and so considered.

5. An induction motor is similar to a transformer in that the number of turns in series in the winding must be varied in the same direction and by the same percentage as any change in the voltage applied. In addition to these principles the following practical considerations must be remembered: a. The new voltage which is applied to a reconnected motor must not exceed the limiting value of the insulation which is on the coils. For example, 2200 volts should not be applied to a 550-volt winding even though it has been reconnected with four times as many turns in series.

b. In reconnecting for higher speeds the peripheral speed of the rotor must be kept down to a safe value so that the centrifugal force does not damage the rotor core or winding mechanically.

c. In a wound-rotor motor the rotor winding must be connected for the same number of poles as the stator winding.

d. In a squirrel-cage motor if radical changes are made in the number of poles, a change may also be required in the short-circuiting rings of the squirrel-cage rotor winding in order to keep the proper starting torque.

e. In a polar-group winding the individual coils at the beginning and end of the phase groups have usually heavier insulation than the inside coils of the groups. Where this is the case, when reconnecting for change in phase or poles the coils with the heavier insulation should be shifted to their proper new places in the winding.

These principles have been thoroughly covered in the articles as they appeared, but in recapitulation some additional comments may be made bearing on the practical application.

1. Cross-Section of Copper and Iron—From the existing connection of the winding in the machine which is to be reconnected, it is a simple matter to check the current flowing in the turns of the coils which are in series. This is done by checking the connection of the winding; that is, whether it is series or parallel, star or delta, etc. From this fact and the rated current of the machine can be derived directly the current in the coils themselves. For example, a three-phase machine has a normal rating of 50 amperes per terminal and is connected 2-parallel delta, Fig. 1. The current in the individual coils themselves is $\frac{50}{2 \times 1.73} = 14.5$ amperes, as shown. Then the load which is put on the motor after reconnection should not be greater than that which would cause 14.5 amperes to flow in the coils themselves. Under the new connection the polar groups might be

5-parallel star, as in Fig. 2, in which case the new current per lead would be 5 × 14.5 amperes = 72.5 amperes, but the current in the individual coils would still be 14.5 amperes as indicated.

If the new connection is for a greater number of poles and hence a slower speed, it would be well not to put quite so much current through as originally on account of the reduction in ventilation. Regarding the cross-section of iron, this remains constant so far as the teeth are concerned, but in the core back of the slots this changes with the number of poles. This is illustrated by Fig. 3, which shows a cross-section of a motor indicating the magnetic conditions in the iron when the motor is connected for 4, 6, 8, 10 or 12 poles.

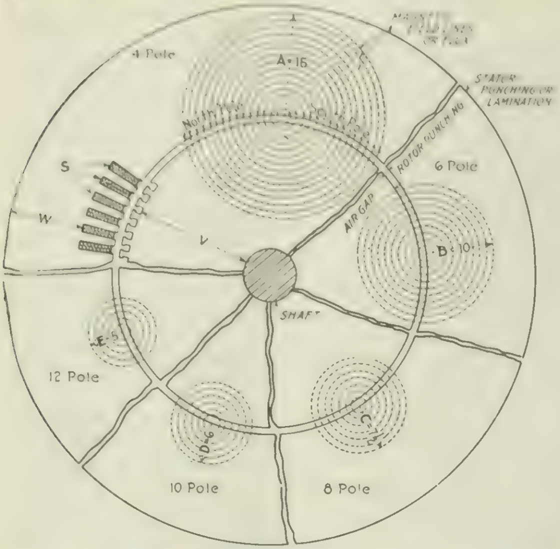


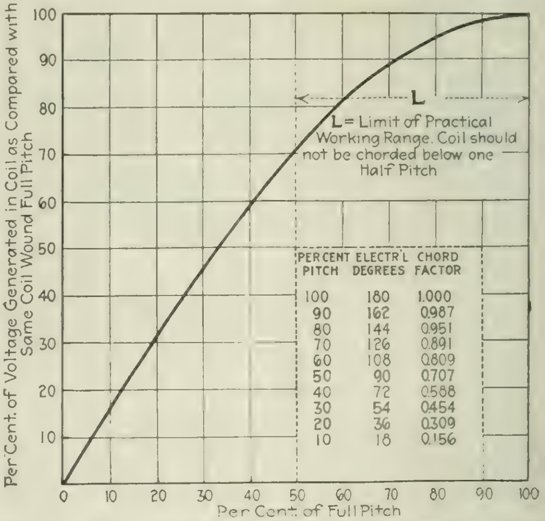
FIG. 3. CORE SECTIONS SHOWING EFFECT ON MAGNETIC FIELD BY CHANGING NUMBER OF POLES

Considering the 4-pole sector, the coils in the stator slots *S* set up a magnetic field represented by the 15 concentric circles causing a north pole where they leave the stator and a south pole where they reënter the stator, as indicated by the arrowheads. The proximity of these 15 circles at the air gap indicates the density of the magnetic field at this location. It will be noted that all 15 of these circles must pass through the core back of the slots or through a cross-section represented by the dimension *W*.

If, now, consideration is given to the sector marked 6-pole, it will be noticed that the magnetic density in the air gap as indicated by the proximity of the concentric circles is the same as in the case of 4 poles, but the iron back of the slots now has to carry only 10 circles and hence has only $\frac{10}{15}$ the magnetic density as in the case of 4 poles. There is still the same total flux in the machine, since 4 × 15 = 60 = 6 × 10, and this explains why the air-gap density stays the same, but this total flux is now separated into six magnetic circuits instead of four and hence the iron in the core back of the slots is not worked nearly so hard.

Similarly, in the case of 8 poles there are only 7½ circles, since 8 × 7½ = 60, and in the case of 10 poles 6 circles and 12 poles 5 circles, since 10 × 6 = 60 and 12 × 5 = 60. In other words, there is the same total flux in the machine for all these connections and the same magnetic density in the air gap, but the core iron back of the slots works at a higher density the smaller the number of poles and at a lower density the larger the number of poles for which the winding is connected. The obvious precaution to be drawn from this consideration is that when reconnecting a winding for a smaller number of poles some check should be made to insure that the magnetic density in the core does not exceed a safe value. Reference will be made to this in a future article on estimating a new winding for an old core.

2. Generator Action of the Winding—This has been referred to several times and will not be elaborated here beyond calling attention to the fact that the rotating magnetic field will always assume such a value that as it cuts the stator coils it will generate in them a voltage practically equivalent to the applied line voltage. Since both the number of turns in series in the coils and the magnetic density in the iron may be varied, there are evidently several combinations that would generate the line voltage, some having more turns and less field and some having less turns and more field. The practical difference between these combinations would be that the fewer the turns and the stronger the field the greater would be the maximum torque, this being limited by the saturation of the iron in the core. A little thought brings out the fact that this is equivalent to raising and lowering the voltage on a fixed winding. The higher the voltage the greater will be the magnetic field and the greater the torque. This consideration of the generated voltage or counter-electromotive force or back electromotive force is one of the simplest checks on the number of turns required in a winding.



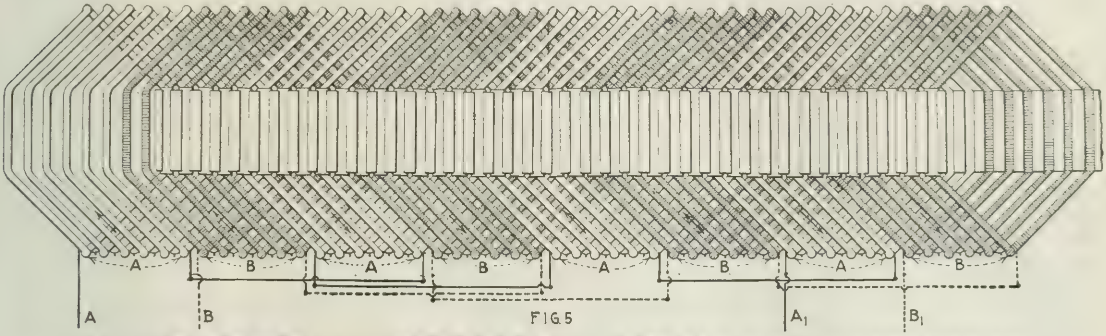
PER CENT PITCH	ELECTR'L DEGREES	CHORD FACTOR
100	180	1.000
90	162	0.987
80	144	0.951
70	126	0.891
60	108	0.809
50	90	0.707
40	72	0.588
30	54	0.454
20	36	0.309
10	18	0.156

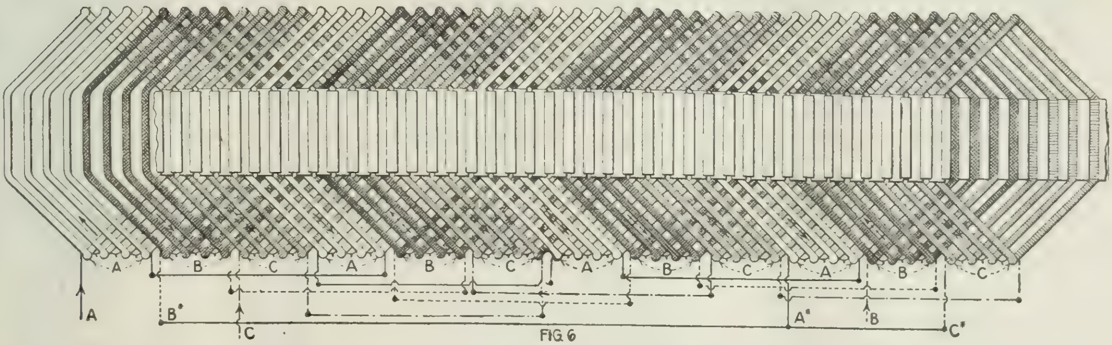
FIG. 4. CURVE SHOWING EFFECTS OF CHORDING A COIL UPON THE VOLTAGE GENERATED

3. The effect of changing the throw has been thoroughly covered, and only the effect on the applied voltage will be shown here as a curve, Fig. 4. In this figure full pitch is called 100 per cent. For example, in a 72-slot 6-pole motor the winding would be 100 per cent. pitch if the coils lay in slots 1 and 13, it would be 66⅔

per cent. pitch if the coils lay in slots 1 and 9 or 50 per cent. if they lay in slots 1 and 7. The curve indicates how the voltage applied to a coil or a winding should be reduced as the coil is chorded up if the same magnetic conditions are to be kept, or the reciprocal of the curve values indicates how the density of the magnetic field will increase if the voltage is held constant while the throw of the coils is decreased.

4. The statement is here made that any change in the operating characteristics of a motor may be reduced to terms of a voltage change and that if the corresponding voltage be applied the operation under the new conditions will approximate the normal operating conditions under the original conditions. Since there are five main operating characteristics—namely, volts, phase, poles, cycles and horsepower—a brief résumé is in order stating how each one of these may be considered as a voltage change. In other words if, for example, the horsepower or phase of a motor is to be arbitrarily changed, what will be the new operating voltage to secure this result? Taking these characteristics in order, a voltage change is self-evident since everything is to be reduced to voltage. In the case of a phase change, two to three or vice versa, the voltage on a three-phase connection should be $\frac{5}{4}$ of that on the corresponding two-phase connection. For example, if a two-phase motor is connected for three-phase and everything else left the same, the three-phase connection should be operated at $\frac{5}{4}$ the rated voltage of the two-phase, or a two-phase 440-volt motor when reconnected for three-phase becomes a 550-volt motor, etc. In Fig. 5 is shown a 48-coil induction-motor winding grouped for two-phase 4-poles, if this winding will operate on 440 volts two-phase it will also operate on 550 volts three-phase when grouped 4-pole series star, as in Fig. 6.





FIGS. 5 AND 6. TWO-PHASE, FOUR-POLE INDUCTION MOTOR WINDING CONNECTED SERIES AND THREE-PHASE, FOUR-POLE INDUCTION MOTOR WINDING CONNECTED SERIES STAR

In the case of a change in the number of poles, if the voltage be changed in the same direction and by the same amount as the change in speed, the torque will remain essentially constant and the horsepower will vary with the speed, being greater at higher speed and less at lower speed in exact proportion. However, if for reasons explained in connection with Fig. 3, there is not enough iron back of the slots to permit of keeping the same total flux and dividing it into fewer circuits with greater flux per circuit, the voltage may be kept constant and the horsepower will remain practically constant. The latter condition would mean that there is less total magnetic flux and less torque at higher speeds and greater total flux and greater torque at lower speeds, as must necessarily be expected since the horsepower is constant and horsepower = torque × r.p.m. ÷ 5252.

A varying frequency can be readily reduced to a corresponding voltage change by remembering that a change in frequency without any other change would result in a change in speed and since the basic idea of this method is that the motor is also an alternating-current generator, generating the applied voltage, it is evident that with an increased speed the generated voltage will be increased and with decreased speed the generated voltage will be decreased. Hence, it follows directly that when the frequency or cycles of the supply circuit are changed the voltage should be changed by the same amount and in the same direction. For example, if a 60-cycle motor is run on 50 cycles it should have applied only $\frac{5}{6}$ the voltage if the same magnetic condition is to be kept, and consequently the horsepower will be only $\frac{5}{6}$ of the 60-cycle value. Viewed mechanically, the torque remains the same on 50 cycles, but the speed is only $\frac{5}{6}$ as great, hence there is only $\frac{5}{6}$ the horsepower which checks the electrical result.

There remains only a change in horsepower to be converted into a voltage change, and this is apparent from the fact that in any motor the horsepower is proportional to the product of the voltage and amperes. Since the cross-section of the copper conductor remains the same and hence the amperes remain the same, the only thing that can vary is the voltage, and it follows directly that to get more horsepower out of a motor requires the application of a higher voltage and less horsepower will permit the use of a lower voltage.

From these considerations it appears that the effect of a change in any of the characteristics of the motor can be balanced by the proper change in the voltage. This statement at once arouses the comment that while it might be found that 273 volts or 346 volts or something of the kind was proper to give normal operation on a motor under changed conditions of phase or poles or what not, still such information would be of little use since there are no commercial circuits having such voltage values. The answer to this is that the number of turns in the winding or the connection of the groups may be changed so as to increase the total number of turns in series by the amount that the voltage should be decreased; and vice versa, it may be possible to decrease the total number of turns per phase in series by the amount that the voltage should be increased.

(The next article will treat a number of practical problems showing how the foregoing may be accomplished.)

Ventilation of Ammonia Condensers

By T. S. SIEBEN
Cooling Plant Inspector, City of Chicago

Types of housing for atmospheric condensers that direct the air through the stands of pipe to carry away the vapor and permit repairs to pan and roof without disturbing the equipment.

In the last few years great developments have been made in ammonia-condenser construction, but often little thought is given to the housing with a view toward attaining the maximum results in operation. The following remarks deal principally with the surface condenser with a preliminary brief review of other types.

Submerged condensers are now practically obsolete. That this condenser was constructed on the countercurrent principle—that is, the coldest water meeting the coldest vapor—and was considered the safest in operation were features given in its favor. On the other hand, it was unwieldy and required a great amount of water. These condensers were generally located indoors close to the compressors, and the open top was usually placed in line with windows to provide for ventilation.

Shell condensers of the early type had cast-iron shells and heads with helical water coils. More modern types are made of steel with welded joints and straight water tubes, the water heads being baffled to provide a multipass arrangement effecting good heat transfer. The construction of the shell type condenser favors minimum friction in the passage of the vapor, thereby keeping the pressure close to theoretical, corresponding to the temperature of the cooling water. Usually, these condensers are placed indoors and no special ventilation is required.

Double-pipe condensers are constructed on the counterflow principle and are usually placed indoors, close to the compressor, making a compact unit. The cooling water passes through the inner pipes and from there is carried off without any vapors being released. In small plants little heat is radiated into the room, but for large outfits ventilation should be provided, the condenser being safeguarded against freezing in the cold weather.

Atmospheric condensers are usually installed in large plants and operate to a great extent on the principle of the cooling effect produced by the evaporation of part of the cooling water when passing over the coils. The usual forms of atmospheric condenser do not favor the counterflow principle; however, some types embody this feature or a compromise in the form of a forecooler. One form of atmospheric condenser developed in the last few years is the flooded type, in which part of the liquefied vapor is reinjected into the condenser and mixed with the incoming dry vapor from the compressor. The wet vapor thus formed tends to produce a heat transfer twice or three times that obtained under the usual conditions.

As a great amount of vapor is released when the cooling water is passed over the condenser, some means of ventilation should be provided. It is customary to place these condensers outdoors or on the roof of a building, preferably shielding them from the sun.

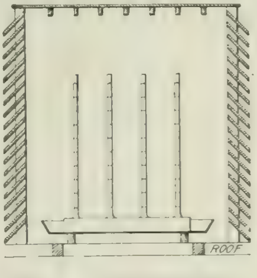


FIG. 1. CONVENTIONAL HOUSING FOR ATMOSPHERIC CONDENSER

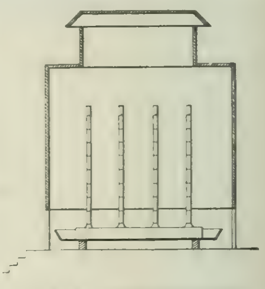


FIG. 2. INTRODUCTION OF CUPOLA OVER CONDENSER

Fig. 1 shows a conventional form of condenser house. The walls are built of louvre work and the entire structure is covered by a tight roof. This construction is based on the theory that the air has access to the condenser from all sides, but as the section on the windward side checks the draft, this supposition does not hold good. The defect in this form of construction can be noticed on cold days when the sluggish vapors are visible near the ceiling. These vapors tend to corrode the condenser and rot the woodwork. A cooling tower is sometimes placed above, and while it cools the water, it does not help to relieve the vapor situation. If a cooling tower is necessary, it should be placed on a separate structure. Some relief from the vapor can be obtained by cutting holes in the roof or better still, by placing a cupola over the condenser to allow the vapors to escape.

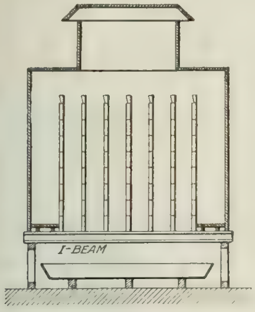


FIG. 3. CONDENSER RESTING ON STEEL BEAMS ABOVE PAN

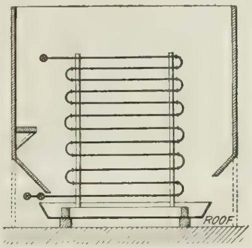


FIG. 4. INEXPENSIVE HOUSING WITHOUT ROOF

Fig. 2 provides for walls closed in on all sides, excepting that the bottom three or four feet are open all around and a large cupola construction placed on the roof. This will permit air to enter at the bottom and rise with the natural flow of the warmer vapor. The condenser rests in a pan on the floor of the condenser house, and the entire structure is raised a few feet so that repairs may be made to the roof.

A variation of construction is shown in Fig. 3. Here the condenser is erected on a framework of steel beams instead of the usual method of placing it in the pan. This allows repairs on the pan to be made without the necessity of disturbing the condenser. Open spaces about the condenser can be filled in by planks so that all entering air must come in contact with the stands of pipe. This design, without the water pan, can be used also for double-pipe condensers, provided steps are taken to prevent freezing.

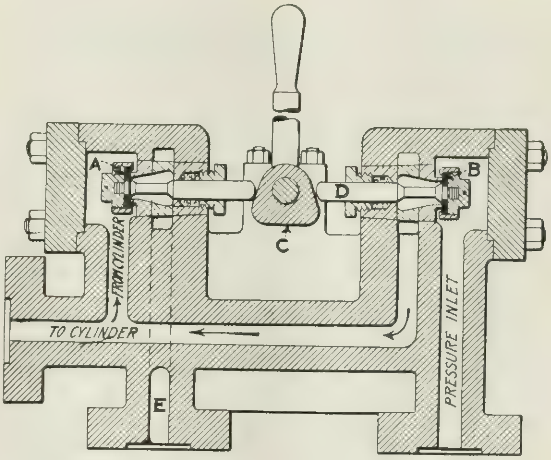
An idea successfully carried out as indicated in Fig. 4 compels the admission of air from under the diagonal bulkheads shown, which protect the liquid and pump-out valves and the headers from flying spray. Overhead gas-inlet valves can be conveniently reached from a runway within the structure. No roof is placed over the condenser and the walls need be only high enough to keep the sun off the pipes. This construction is perhaps the least costly of all to build.

It has been demonstrated that with a suitable form of condenser housing a great saving can be effected in water and power bills and that the head pressure may be lowered to a safer working condition. Under moderate working conditions, due to the lower pressure, and particularly if a liberal-sized condenser is employed, the cooling water can be re-used without passing through a cooling tower. In freezing weather the condenser can often be operated dry without unduly raising the vapor pressure.

Hydraulic Operating Valve

Hydraulic operating valves are used for various purposes where hydraulic pressure is the medium for moving a piston in a cylinder. A new operating valve, recently placed on the market by the Vance-Vetter Co., Pittsburgh, Penn., contains, as its principal feature, a flat disk made from either leather or fiber, which can be easily renewed without disconnecting the valve or piping. This feature is shown at *A* and *B* in the illustration.

In operation, the water pressure enters the valve through the pressure-inlet connection, but cannot pass through while the handle remains in the central or upright position. Pushing the handle forward to the open position brings the cam *C* against the valve stem *D* and forces the valve *B* from its seat, allowing the pressure to pass through the valve opening into the part leading to the cylinder. Pulling the handle back to the central position allows the inlet pressure to close the valve. When the handle is moved back beyond the central position, the cam *C* opens the valve *A* and allows the return water to come back through the same pipe and discharge through the valve opening, to the waste-water outlet *E*.



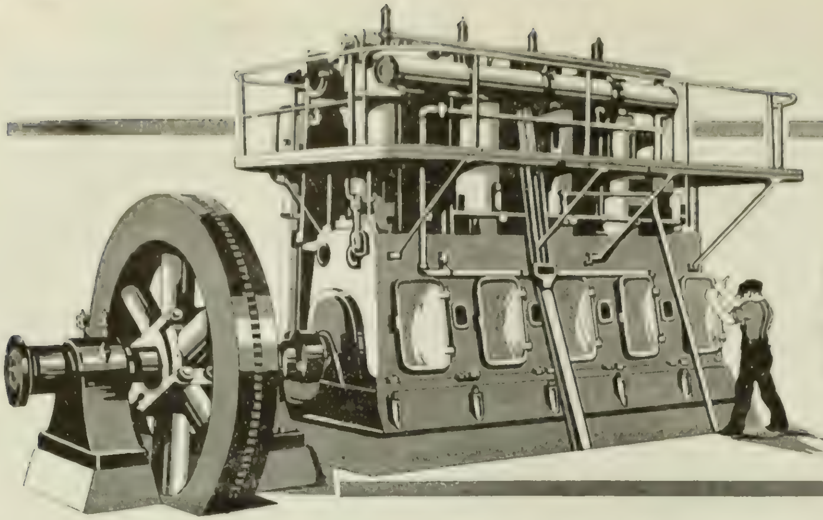
SECTION THROUGH OPERATING VALVE

As the valves are operated by a cam movement, they have a positive stop for open and closed positions and cannot creep. When the handle is released to the center position, it centers and closes the valve automatically.

This valve is designed for pressures up to 3000 lb. per sq.in. and will work without sticking with muddy or sandy water.

If the rotative speed of an engine is increased, other conditions remaining unchanged, the quantity of steam used per horsepower per hour will decrease. This is because there is less time for heat transfer between the cylinder walls and the steam and also for the loss of heat through radiation.

If the ammonia charge in an absorption system contains 0.6 per cent. or more of carbon dioxide, a sludge of black iron oxide mixed with free carbon will be formed by the action of oxygen on the iron pipes.



Talks on DIESEL Engines

by
L. H. Morrison

XI—Takes up the construction and action of fuel valves of various forms and points out how to care for such valves.

"WHAT one thing about fuel valves bothers you most?" was Egan's general inquiry at the opening of the next meeting.

Woods was ready to seize the opportunity.

"Why is air used to blow the oil into the cylinder?" he asked. "Why not shoot it straight from the pump, as in the hot-ball engine?"

"Impossible," Egan replied. "In a hot-ball engine the compression is low and the temperature won't explode the oil prematurely, so that pump injection is possible. But in a Diesel the compression temperature is high and at heavy loads may be high enough to ignite an oil charge early in the stroke, so that pump injection would be dangerous. If a cam-operated needle valve is placed between the pump and the nozzle, however, pump injection can be used. The main difficulty is that it takes a pressure of about 2500 lb. per sq.in. to atomize the oil."

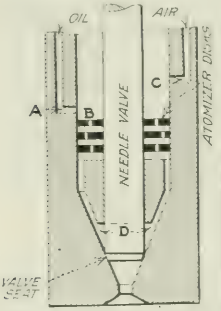


FIG. 1. CLOSED TYPE OF FUEL NOZZLE

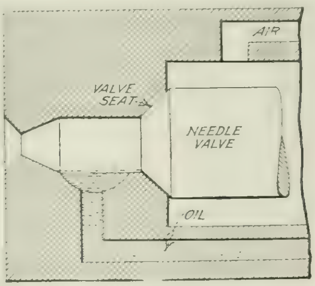


FIG. 2. OPEN TYPE OF FUEL NOZZLE

"First thing, J. R.," Kelly broke in, "I want you to explain the meaning of open and closed nozzles. The other day a salesman dropped in, and he spoke of his engine using an open nozzle. He had my number on that, but I didn't care to show myself up as a sort of ignoramus by asking what he meant."

At the next meeting the chief will talk to the class about the construction of fuel pumps and their operation

"Kelly, the air-fuel injection systems, as we will call them, can be separated into two classes. The first employs a fuel valve where the oil is deposited by the pump, in contact with the highly compressed air, behind the needle valve. That is, the needle valve is between the combustion chamber and the fuel charge. When the needle valve opens, the air blows the fuel past the valve seat into the combustion chamber. Fig. 1 shows the closed nozzle and the open type is outlined in Fig. 2. In the latter the fuel is deposited beyond the needle valve and is in open communication with the combustion chamber. When the needle valve opens, the air current picks up the oil and blows it into the cylinder.

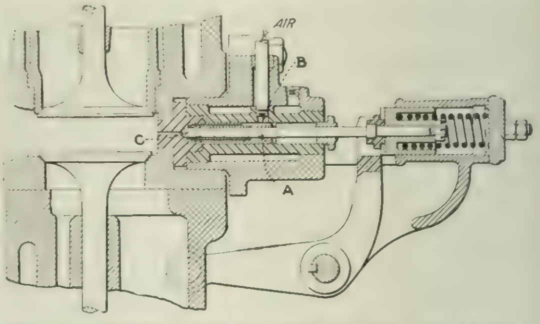


FIG. 3. CLOSED TYPE OF NOZZLE USED ON EARLY AMERICAN ENGINES

"The closed type has been in longer use and has been adopted by the majority of builders, so we'll take up a few examples of the closed nozzle. First let us take the one used on our American engine, as it is the forerunner of those used on American engines. Fig. 3 is a cross-section of the valve body and parts. The oil is fed in horizontally at *A* and flows along to a point just behind the valve seat. The air enters at *B* and is behind the oil charge. When the needle valve *C* opens, the air blows the oil through a row of minute ports into the nozzle passage. A sketch of the atomizer is given in Fig. 4. The fault of this atomizer appears to be that the passage of the oil through the ports doesn't provide enough atomization. If the load is light and the charge small, there is no atomization, so we needn't be surprised if the engine smokes on light loads. Another defect is that the lack of resistance in the atomizer lets too much air blow through on light loads. I'd be willing to bet that twice as much air is used on light as on heavy loads, when the air pressure is kept the same. The result is that the output of the engine is low in comparison with the indicated horsepower. If the load is continuously light, the air pressure should be reduced by throttling the air-compressor suction and cutting out the air-bottle line.

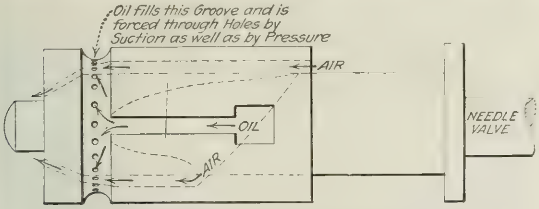

Oil fills this Groove and is forced through Holes by Suction as well as by Pressure
AIR
OIL
AIR
NEEDLE VALVE

FIG. 4. ATOMIZER OF NOZZLE SHOWN IN FIG. 3

"The majority of closed nozzles are similar to the simple form in Fig. 1. The oil passes down the passage *A* to a position over the atomizer *B*. The air is forced through the port *C* into the valve body above the oil. The atomizer consists of a series of perforated disks with the holes staggered. The oil, on entering the valve cavity, flows down through the disks and fills the spaces in the atomizer as well as the passages *D* behind the valve seat.

"The governing is effected, almost without exception, by regulation of the fuel deposited in the valve, although a few have experimented with the plan of varying the opening of the fuel valve. The atomizer serves a double purpose—to atomize the oil and mix it with the air and to control the flow of air and oil so that the entire charge will not enter the combustion chamber when the valve first opens. This latter effect is called 'braking' and is probably the more important of the two."

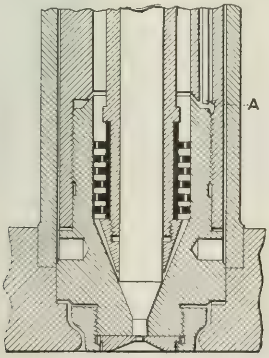


FIG. 5. FUEL NOZZLE OF BUSCH-SULZER ENGINE

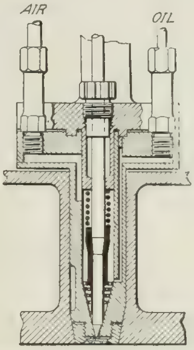


FIG. 6. FUEL NOZZLE OF FULTON ENGINE

"Chief, what engines use that kind of atomizer?" Woods inquired.

"As I stated, a great number use some similar design. The cross-section, Fig. 5, is of the Busch-Sulzer valve."

"Mr. Egan, what is that rod *A* for? I saw it the other day when we had one of the valves out, and even Kelly didn't know the why of it." The Scotsman asked the question.

"That is a dandy little scheme, and every engine ought to have some such arrangement. That rod is made of aluminum and rests in the oil line. If the fuel is a very light distillate, the temperature of the valve body might cause carbonization. This little rod shakes around due to the vibrations of the engine and so keeps the passage clear. When a heavy oil is used, quite often a sediment will deposit in the passage, and this wiggling stick acts as a policeman, keeping the oil traffic on the move down the passage."

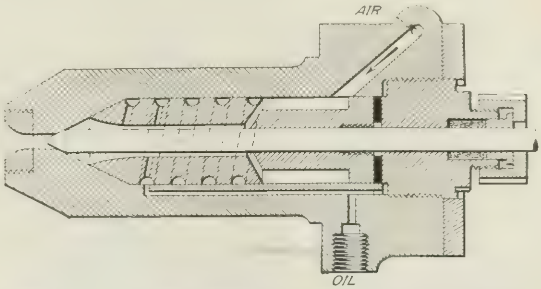


FIG. 7. FUEL NOZZLE FOR HORIZONTAL ENGINES

"Well, J. R.," asked Kelly, "what's your kick against this kind of valve?"

"You fellows mustn't get the idea I'm a chronic kicker," protested Egan. "I merely take the stand that the bad features should be pointed out. The good points show up in the continued operation of an engine. But I don't intend to allow Kelly's snarky question to stop me. All valves built along the line of this one need improvement. When the oil charge is large, as on heavy loads, it is forced down through the atomizer by the air and fills the entire space in the atomizing disks as well as the space behind the valve seat. When the valve opens, the oil just behind the valve at once flows into the cylinder without being broken up, and the combustion is imperfect. The braking effect on the air and oil mixture that passes through the disks is increased due to the greater resistance. The combustion is drawn out over a longer period than is desirable, and the combustion line on the indicator card is sloping rather than fairly horizontal.

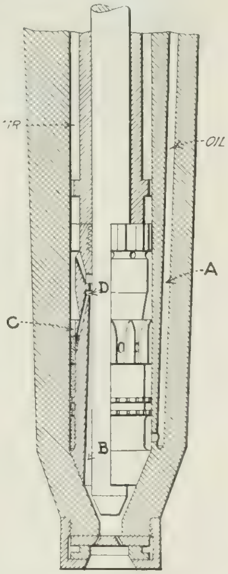


FIG. 8. HESSELMANN ATOMIZER

"Now take the case where the fuel charge is light. It does not flow so readily through the disks owing to its lighter weight, and so does not displace the air below the disks. When the valve opens, the trapped air is first to enter the cylinder. This cools the combustion chamber and delays the burning of the fuel that follows. Furthermore, since the fuel charge is smaller, it enters the cylinder at a higher rate and of course in a shorter time. Then during a considerable part of the time the needle valve is open, nothing but air blows through the atomizer. The braking action of the atomizer has but little effect on the air, and a far greater amount of air enters the combustion chamber than in case of full load. This is the reason that on low loads the actual friction horsepower is more than on full load. The nozzle used in the Fulton engine is shown in section in Fig. 6.

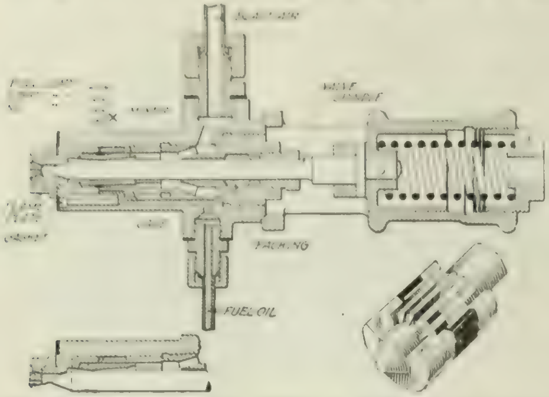


FIG. 9. NOZZLE USED BY GENERAL ELECTRIC COMPANY

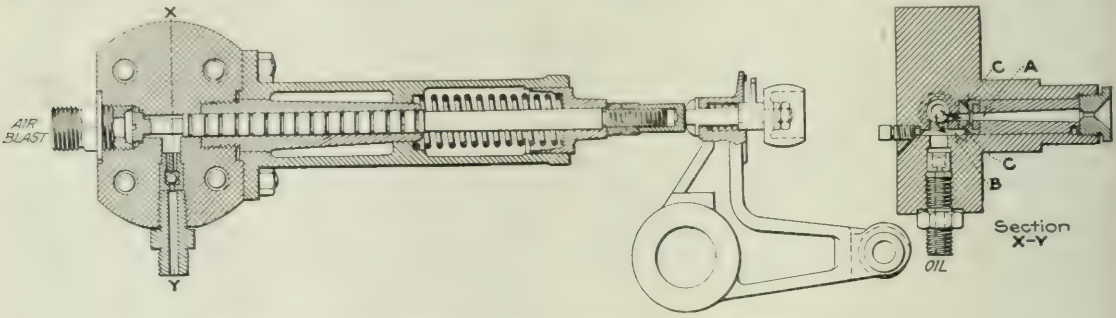


FIG. 10 TYPE OF FUEL VALVE AND NOZZLE USED ON McEWEN ENGINE

"If we increase the air pressure, or decrease the resistance of the atomizer, the rate of flow will increase. So it could well be expressed by an equation:

$$\textit{Rate of injection} = \frac{\textit{pressure difference}}{\textit{resistance of atomizer}}$$

"The pressure difference is the difference between the injection-air pressure and the cylinder-compression pressure. This equation indicates, then, that if the resistance is kept constant, the only way to vary the rate of injection is by varying the air pressure, as by the use of an automatic device. In engines not having automatic adjustment, the pressure variation can be secured by hand adjustment of the compressor intake. This applies only when the load does not swing, and of course an operator can only care for those load variations that are of considerable duration.

"Another fact worth remembering is that the resistance of an atomizer bears no relation to the degree of atomization secured. It's apparent that the disk form of atomizer has a great resistance and for the same rate of injection the pressure must be kept higher than in the case where the resistance is low. The main object is to secure low resistance with high atomization, so as to lower the compressor horsepower.

"Fig. 7 is the fuel valve used on horizontal engines, or in a horizontal position on vertical engines. The fuel is introduced into the spiral close to the needle valve. The greater the oil charge, the farther the fuel backs up in the spiral. The air passage allows an expansion of the air with a pressure reduction, as the valve opens. This pressure difference forces the oil into the air with fair atomization. The resistance of the atomizer varies with the oil charge. With a heavy charge the oil will flow down around the valve seat and the first particles entering the cylinder will be poorly mixed.

"Fig. 8 outlines the Hesselmann atomizer used on the McIntosh & Seymour engine. The oil flows down the passage *A* shown and is deposited around the atomizer, as indicated by the stippled area in the cross-section. As the valve opens, the air sweeps down along the valve stem, and as the passage *B* has an increasing cross-section, the pressure decreases. The air, at full pressure, rests on the oil at *C* and this unbalancing of pressures causes the oil to start to flow toward the valve stem at *D*. Once this action is set up, the entire charge of oil is supposed to be drawn into the air stream by an injector effect, but in practice this is not achieved to entire satisfaction. Part of the oil remains at the bottom. On the next charge, if it is full load, the oil level rises and overflows into the air passage around the valve stem. The result is that some oil collects around the valve seat or blows into the cylinder unatomized. The big advantage of this type of valve lies in its low resistance, and this means a lower injection air pressure. Fig. 9 is a valve used by General Electric Co. that uses the same principle of unbalanced air pressure.

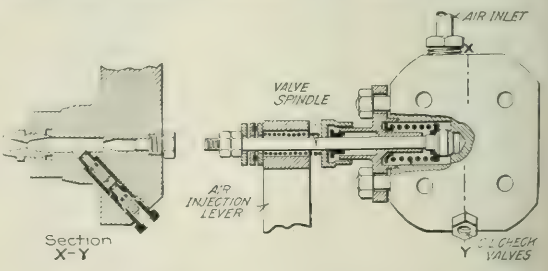


FIG. 11. FUEL NOZZLE OF ALLIS-CHALMERS ENGINE

"Coming now to open nozzles, Fig. 10 shows the valve used in the McEwen engine. Part of the air charge passes directly through the central opening into the tube *A*, as indicated by the arrows in the section *XY*. The expansion taking place causes the resulting unbalanced air pressure at *B* to force the oil through the ports *C* into the tube, where it mixes with the air.

"Fig. 11 outlines the Allis-Chalmers nozzle, which is also of the open type."

"What's the advantage of this kind of valve, chief?" Kelly asked.

"Well," Egan replied, "it has a low resistance, so that it's possible to use an air pressure at least 15 per cent. lower than that used with a closed nozzle. There is no highly compressed air in contact with the fuel. If the oil should ignite prematurely, no great damage can be done, as the oil receptacle is in communication with the cylinder. It would be practically impossible to make it burn since it is surrounded by foul gases instead of pure air. But the open nozzle has disadvantages, too. The atomization is far from perfect, and the oil is delivered to the cylinder in slugs rather than in minute particles. In fact, the only atomization that takes place occurs at the nozzle tip. There is a tendency toward smoking due to this poor mixing of the air and the oil.

"Getting down now to practical operation, the valve should be cleaned once every month. Don't let yourself be kidded by the quiet running of the engine into neglecting this. To clean the valve, soak all the parts for a couple of hours in kerosene. Then clean each passage and corner thoroughly with a thin steel bodkin. The valve should be ground. This is a particular job and should be carefully done. Often the valve stems pit owing to sulphur in the oil. If this occurs, use emery cloth and put the surface in good shape. In packing the valve stuffing-box, use shredded lead. You can buy it from a supply house and it beats any other packing I know. It's also very necessary to maintain a good spring pressure. If regrinding has shortened the length of the stem, you can slip a washer above the spring and tighten it down with the adjusting setscrew."

"Chief, why is the nose of the fuel cam adjustable?" Woods asked.

"You will find that different oils require different periods of injection, and the adjustable nose allows the point of injection to be varied. Another thing—the wear on fuel cams is much more than on the exhaust- and inlet-valve cams, and the adjustable nose allows this wear to be corrected.

"Now, boys, it's late and I'll speak of only one more thing, the method of going about setting valves.

"When a new engine is installed, a good many manufacturers supply prints showing the valve setting. In case you have such a print, set the needle valves first. To do this, unscrew the plug in the exhaust elbow and block open the exhaust valve, or remove the indicator plug on the cylinder. Now turn your engine in the direction of rotation, and crack the air-line valve. When you have rotated the flywheel to the point at which the needle valve should open, if the valve is properly set, you can hear the air rush out through the nozzle. Turn the engine over slowly and see if the valve closes properly. If the point of opening is wrong, adjust the movable cam nose. Then turn the engine backward a considerable distance and bring it forward slowly."

"What's the reason of turning backward?" one of the men put in.

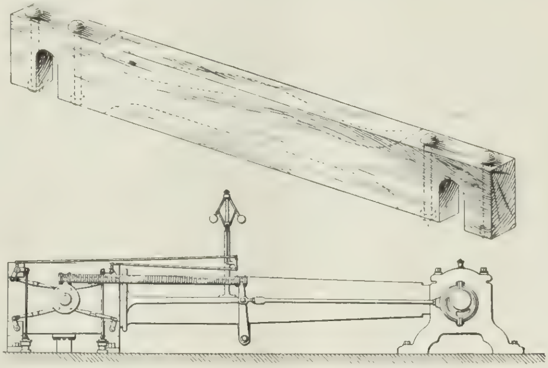
"That's to take up the effect of backlash in the gears. After getting the opening correct, test for point of closure. If this is wrong, it is possible to grind the cam nose to correct it. Before doing so, it's a good plan to check all the valves. Then if they are all out, it may be possible to either advance or retard the position of the cams by changing the gears by one tooth. After you have checked the fuel valves, take up the exhaust and the admission valves."

"Chief, I notice you check all the valves as they come when turning the engine over," spoke up Kelly.

"That is true, and it's quicker to do it that way; but for a beginner it's best to check them as I have just described."

Engine Repair Kept Mine Plant Running

The accompanying illustration shows an emergency repair to a Corliss engine. The rod transmitting motion between the rocker arm and the wristplate broke in such a way that it could not be repaired readily at the mine plant. The master mechanic was hurriedly called. In the course of a comparatively short time he had ascertained the exact distance between the rocker-arm and wristplate pin centers, and the diameters of these pins. This distance center to center he laid out accurately on an oak plank of suitable dimensions.



EMERGENCY REPAIR TO CORLISS ENGINE

About this time a carpenter that he had sent for arrived with a brace, an expansion bit, a square and a saw. First, holes of the diameter of the two pins were bored at the center points previously determined. The portion of the plank lying between these holes and one edge was then cut out, making a round-bottomed notch. The plank was then slipped over the pins on the valve gear and the engine started.

A new rod was of course immediately ordered. At the first opportunity the carpenter trimmed up the plank-valve rod substitute to the outline indicated by the dotted lines in the illustration. This rendered the plank much lighter, while leaving ample strength to work the wristplate. Two small carriage bolts were also added at either end to prevent splitting.

This wooden rod, while it looked sufficiently ungainly to jar upon the nerves of any artistically inclined power-plant man, kept the engine running and prevented a shutdown until the new rod arrived. It was then stored away against a future emergency.

Areas of Segments of Boiler Heads

To do away with tedious formulas and long calculations tables are given by which the area of a segment of a boiler head to be stayed may be found directly with sufficient accuracy for all practical purposes.

THAT part of the flat head of a boiler between the upper row of tubes and the shell is a segment of a circle, and its area must be found in order that proper provision may be made for staying. The tubes are assumed to offer sufficient support for a distance of 2 in., and the flange of the head is assumed to support the head for a distance that varies according to the thickness of the plate and the pressure to be carried.

The latest revision of the A. S. M. E. Boiler Code states that the area of a segment to be stayed shall be the area inclosed by lines drawn 2 in. from the tubes and at a distance *d* from the shell, as shown in Figs. 1 and 2. The value of *d* to

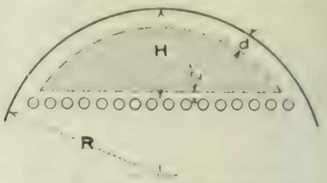


FIG. 1. REGULAR SEGMENT ABOVE TUBES

NET AREAS OF SEGMENTS OF

Values of the Term

(H-d-2) Inches	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	31½
3	22	24	26	28	30	31	33	34	35	37	38	39	41	42	43	44	45	46	47								
3½	27	30	32	35	37	39	41	43	44	46	48	49	51	52	54	55	57	58	59								
4	33	36	39	42	45	47	50	52	54	56	58	60	62	64	65	67	69	70	72	74							
4½	39	43	46	50	53	56	59	61	64	66	69	71	73	76	78	80	82	84	86	87							
5	45	49	54	58	61	65	68	71	74	77	80	83	86	88	91	93	95	98	100	102	104	106	*Areas of Segments To Be*				
5½	51	56	61	66	70	74	78	82	86	89	92	95	98	101	104	107	110	112	115	117	120	122					
6	57	63	69	74	79	84	88	93	97	101	104	108	111	115	118	121	124	128	131	133	136	139	141				
6½	63	70	77	83	88	94	99	104	108	113	117	121	125	129	133	136	140	143	146	150	153	156	159				
7	69	77	84	91	98	104	110	115	120	125	130	135	139	144	148	152	155	159	163	167	171	174	178				
7½	75	84	93	105	108	114	121	127	133	138	143	148	154	158	163	168	172	176	181	185	189	193	197	200	204		
8					117	125	132	139	145	151	157	163	168	174	179	184	189	193	198	203	207	211	216	220	224		
8½					127	135	143	151	158	165	171	177	183	189	195	201	206	211	216	221	226	231	236	240	245		
9					137	146	155	163	171	178	185	192	199	205	211	217	223	229	235	240	245	251	256	260	265	270	273
9½					147	157	167	176	184	192	200	207	215	222	228	235	241	248	254	260	266	272	276	280	283	286	289
10					157	168	178	188	197	206	215	223	231	238	246	253	260	266	273	279	286	292	298	304	310	315	318
10½					167	180	190	201	211	220	230	238	247	256	264	271	278	285	293	300	306	313	319	326	332	338	341
11								214	225	235	245	254	263	272	281	289	297	305	313	320	327	334	341	348	355	362	368
11½								227	238	249	260	270	280	290	299	308	317	325	333	341	349	357	364	371	378	386	389
12								240	252	264	276	286	297	307	317	326	336	345	354	362	371	379	387	395	402	410	414
12½											291	303	314	325	335	346	355	365	375	384	392	401	410	418	426	434	438
13											307	319	331	342	354	365	375	386	396	406	415	424	434	442	451	460	464
13½											322	336	349	361	373	384	396	407	417	427	438	448	457	466	476	485	490
14											338	353	366	379	392	404	416	428	439	450	460	471	481	491	501	511	516
14½											355	369	384	398	411	424	436	449	461	472	484	495	506	516	527	537	542
15											371	386	401	416	430	444	457	470	483	495	507	519	530	541	552	563	569
15½														435	450	464	478	492	505	518	531	543	555	567	579	590	595
16														454	469	485	499	514	528	542	555	568	580	593	605	617	623
16½														473	489	506	521	536	550	565	579	592	606	619	632	644	650
17														492	509	526	542	558	573	588	603	618	632	642	659	672	678
17½																546	564	580	596	612	628	643	657	672	686	699	706
18																567	585	603	620	636	652	668	683	698	713	727	734
18½																588	607	625	643	660	677	694	709	725	742	756	763
19																609	629	648	667	684	703	719	736	752	769	784	792
19½																	651	671	690	708	727	745	763	780	795	813	821
20																	673	694	714	734	753	771	789	807	825	843	850
20½																	695	716	738	758	778	797	816	835	853	871	880
21																	717	739	760	782	803	824	844	863	882	900	909
21½																				807	829	851	871	891	910	929	939
22																						876	898	919	940	960	969
22½																						903	925	948	969	989	999
23																						930	954	976	997	1019	1030
23½																							981	1004	1027	1049	1060
24																							1008	1033	1056	1079	1091
24½																							1037	1061	1085	1109	1121
25																							1064	1090	1115	1139	1152
25½																										1170	1183
26																										1201	1214
26½																										1232	1245
27																										1263	1276
27½																											
28																											
28½																											
29																											
29½																											
30																											
30½																											
31																											
31½																											
32																											

VALUE OF *d*, OR DISTANCE SUPPORTED BY FLANGE OF HEAD

Thickness of Head, In.	Working Pressure, Pounds Per Square Inch													
	50	60	70	80	90	100	110	120	130	140	150	160	170	180
	Distance Supported by Flange, Inches													
$\frac{3}{8}$	3.00	3.00	3.00	3.00	3.00	3.00	2.86	2.75	2.63	2.53	2.45	2.37	2.30	2.23
$\frac{7}{16}$	3.50	3.50	3.50	3.50	3.50	3.50	3.33	3.21	3.07	2.95	2.85	2.77	2.68	2.60
$\frac{1}{2}$	4.00	4.00	4.00	4.00	4.00	4.00	3.81	3.66	3.50	3.38	3.26	3.16	3.06	2.98
$\frac{9}{16}$	4.50	4.50	4.50	4.50	4.50	4.50	4.29	4.12	3.95	3.80	3.67	3.56	3.44	3.35
$\frac{5}{8}$	5.00	5.00	5.00	5.00	5.00	5.00	4.77	4.58	4.38	4.22	4.08	3.95	3.83	3.72
$\frac{11}{16}$	5.50	5.50	5.50	5.50	5.50	5.50	5.24	5.04	4.82	4.64	4.49	4.35	4.22	4.10
$\frac{3}{4}$	6.00	6.00	6.00	6.00	6.00	6.00	5.72	5.50	5.26	5.07	4.90	4.74	4.60	4.47
$\frac{13}{16}$	6.50	6.50	6.50	6.50	6.50	6.50	6.20	5.96	5.70	5.49	5.31	5.14	4.98	4.84
$\frac{7}{8}$	7.00	7.00	7.00	7.00	7.00	7.00	6.67	6.42	6.14	5.91	5.71	5.53	5.37	5.21
$\frac{15}{16}$	7.50	7.50	7.50	7.50	7.50	7.50	7.15	6.88	6.57	6.33	6.12	5.93	5.75	5.59
1.0	8.00	8.00	8.00	8.00	8.00	8.00	7.63	7.33	7.00	6.76	6.53	6.32	6.13	5.96

be used in any particular case may be the larger of the following values, which are quoted directly from Par. 214 of the Boiler Code:

(1) d = Outer radius of flange, not exceeding eight times the thickness of the head.

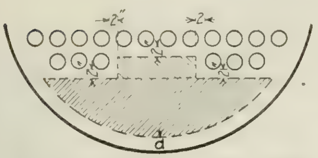


FIG. 2. IRREGULAR SEGMENT BELOW TUBES

(2) $d = \frac{5 \times T}{\sqrt{P}}$

in which

d = Unstayed distance from shell, in inches;

T = Thickness of head, in sixteenths of an inch;

P = Maximum allowable working pressure, in pounds per square inch.

After the value of d has been found for a particular case, it is subtracted from the radius of the boiler, giving $(R - d)$, which is the radius of the curved edge of the segment whose area is to be found. The height of this segment is the distance from the tubes to the shell less the distance d supported by the flange and the 2 in. supported by the tubes, or $(H - d - 2)$. These two quantities having been found, the area of the segment in square inches may be calculated by using the formula,

$$Area = \frac{4(H-d-2)^2}{3}\sqrt{\frac{2(R-d)}{(H-d-2)} - 0.608}$$

To do away with calculations of d, the two small tables are given. The first was prepared by F. R. Burlingame and covers the values of d for all pressures from 50 to

BOILER HEADS TO BE BRACED

(R − d, in Inches

Stayed, in Square Inches

VALUE OF d, OR DISTANCE SUPPORTED BY FLANGE OF HEAD

Thickness of Head, In.	190	200	210	220	230	240	250	260	270	280	290	300	310	320
	Working Pressure, Pounds per Square Inch													
	Distance Supported by Flange, Inches													
3/8	2.17	2.12	2.07	2.02	1.98	1.94	1.90	1.86	1.83	1.79	1.76	1.73	1.70	1.68
7/16	2.54	2.47	2.41	2.36	2.31	2.26	2.21	2.17	2.13	2.09	2.05	2.02	1.99	1.96
1/2	2.90	2.83	2.76	2.69	2.64	2.58	2.53	2.48	2.43	2.39	2.35	2.31	2.27	2.24
9/16	3.26	3.18	3.11	3.03	2.97	2.90	2.85	2.79	2.74	2.69	2.64	2.60	2.56	2.52
5/8	3.63	3.54	3.45	3.37	3.29	3.23	3.16	3.10	3.04	2.98	2.94	2.89	2.84	2.79
11/16	3.99	3.89	3.80	3.71	3.63	3.55	3.48	3.41	3.35	3.29	3.23	3.17	3.12	3.07
3/4	4.35	4.24	4.14	4.04	3.95	3.87	3.79	3.72	3.65	3.58	3.52	3.46	3.41	3.35
13/16	4.72	4.59	4.49	4.38	4.29	4.20	4.11	4.03	3.96	3.88	3.82	3.75	3.69	3.63
7/8	5.08	4.95	4.83	4.71	4.61	4.52	4.43	4.34	4.26	4.18	4.11	4.04	3.98	3.91
15/16	5.44	5.30	5.17	5.06	4.95	4.84	4.74	4.65	4.56	4.48	4.40	4.33	4.26	4.19
1.0	5.80	5.66	5.52	5.40	5.27	5.16	5.06	4.96	4.87	4.78	4.70	4.62	4.54	4.47

32	32½	33	33½	34	34½	35	35½	36	36½	37	37½	38	38½	39	39½	40	40½	41	41½	42	42½	43	43½	44	44½	45	(H-d-2) Inches
																											3
																											3½
																											4
																											4½
																											5
																											5½
																											6
																											6½
																											7
																											7½
																											8
																											8½
																											9
																											9½
321																											10
344																											10½
371																											11
392	395																										11½
417	421																										12
442	446	450	454																								12½
468	472	476	480																								13
494	498	503	507																								13½
520	525	529	534																								14
547	552	556	561	566	571																						14½
574	579	583	589	594	599																						15
601	606	612	618	623	628	633																					15½
629	634	640	645	651	657	662																					16
656	662	668	674	680	686	692	698	704																			16½
685	691	697	704	710	716	722	728	734																			17
713	719	726	733	739	746	752	758	764	770	776	782	788	794	800	806	812	818	824	830	836	841	846	851	856	861	866	17½
742	749	756	763	769	776	782	789	796	802	808	815	822	829	835	841	847	853	859	865	871	877	883	889	894	899	904	18
770	778	785	792	799	806	813	820	827	833	840	847	854	861	868	875	882	889	895	901	907	913	919	925	931	937	942	18½
799	807	815	822	829	837	844	851	858	865	872	879	886	893	900	907	914	921	928	935	942	949	956	962	968	974	980	19
829	837	845	852	860	868	876	883	890	898	905	912	919	927	934	941	948	955	962	969	976	983	990	997	1004	1011	1018	19½
859	867	875	883	891	899	907	915	923	930	938	946	953	961	969	977	985	992	999	1006	1013	1020	1027	1034	1041	1048	1054	20
888	897	905	914	922	930	938	947	955	963	971	978	986	994	1002	1010	1018	1026	1034	1041	1048	1055	1062	1069	1076	1083	1090	20½
918	927	936	945	953	962	970	979	988	995	1004	1012	1020	1029	1037	1045	1053	1061	1069	1077	1084	1091	1098	1105	1112	1119	1126	21
949	957	966	976	985	994	1003	1011	1020	1029	1037	1046	1054	1063	1072	1081	1089	1097	1105	1113	1121	1129	1136	1143	1150	1157	1164	21½
979	988	997	1007	1016	1026	1035	1044	1053	1062	1071	1080	1089	1097	1106	1114	1122	1130	1138	1146	1154	1162	1170	1178	1186	1194	1202	22
1009	1019	1029	1039	1048	1058	1068	1077	1087	1096	1105	1114	1123	1132	1141	1150	1159	1168	1176	1184	1192	1200	1208	1216	1224	1232	1240	22½
1040	1050	1061	1071	1080	1090	1100	1110	1120	1130	1139	1148	1158	1167	1176	1185	1194	1203	1212	1220	1229	1238	1247	1255	1263	1271	1279	23
1071	1081	1092	1102	1113	1123	1133	1144	1154	1163	1173	1183	1193	1203	1212	1222	1231	1240	1249	1258	1267	1276	1285	1294	1303	1312	1320	23½
1102	1113	1124	1134	1145	1156	1167	1177	1187	1198	1208	1218	1228	1238	1248	1258	1268	1278	1288	1297	1306	1315	1324	1333	1342	1351	1360	24
1132	1144	1156	1167	1178	1188	1200	1211	1222	1233	1243	1253	1264	1274	1285	1295	1305	1315	1325	1335	1345	1355	1365	1374	1383	1392	1401	24½
1164	1176	1187	1199	1211	1222	1233	1245	1256	1267	1277	1288	1299	1310	1321	1331	1342	1352	1362	1372	1382	1392	1402	1412	1422	1432	1442	25
1196	1208	1220	1232	1244	1255	1267	1278	1290	1302	1313	1324	1335	1346	1357	1368	1379	1389	1399	1410	1421	1432	1442	1452	1462	1472	1482	25½
1226	1239	1252	1265	1276	1289	1301	1313	1325	1337	1348	1360	1371	1383	1394	1405	1416	1427	1439	1450	1461	1472	1483	1493	1503	1513	1523	26
1258	1272	1285	1298	1311	1323	1335	1347	1360	1372	1384	1396	1407	1419	1431	1442	1453	1465	1476	1487	1498	1509	1520	1531	1544	1554	1564	26½
1290	1303	1315	1330	1343	1356	1370	1382	1395	1407	1419	1431	1443	1456	1468	1479	1491	1503	1515	1527	1539	1551	1563	1574	1585	1596	1607	27
			1363	1376	1390	1405	1417	1430	1443	1455	1468	1480	1493	1505	1518	1529	1542	1554	1565	1577	1590	1602	1614	1626	1638	1650	27½
			1397	1410	1424	1439	1452	1465	1478	1491	1504	1517	1529	1542	1555	1567	1580	1592	1604	1616	1628	1640	1652	1664	1676	1687	28
			1430	1445	1459	1473	1486	1501	1513	1527	1540	1554	1567	1580	1593	1606	1618	1631	1644	1657	1669	1681	1694	1707	1720	1733	28½
			1462	1477	1493	1507	1521	1535	1549	1564	1578	1591	1605	1618	1632	1645	1658	1671	1684	1697	1710	1722	1735	1748	1761	1774	29
									1585	1599	1613	1628	1642	1656	1670	1682	1696	1710	1723	1737	1750	1763	1777	1790	1803	1816	29½
									1620	1635	1650	1666	1680	1694	1708	1722	1736	1750	1763	1776	1789	1804	1817	1830	1843	1856	30
															1748	1760	1775	1789	1803	1817	1831	1844	1858	1872	1886	1900	30½
															1788	1800	1814	1828	1843	1858	1872	1886	1900	1914	1928	1941	31
																					1913	1928	1942	1957	1969	1985	31½
																					1955	1969	1984	1997	2011	2028	32

180 lb. per sq. in. The second small table gives values of d for pressures from 180 to 320 lb. per square inch.

The main table gives the areas of segments to be braced and is based on values of $(R - d)$ and $(H - d - 2)$ differing by half-inches except for values of $(R - d)$ below 31 in.

Suppose that a boiler 54 in. in diameter has a head ½ in. thick and is to carry a working pressure of 180 lb., and that the distance from the top of the tubes to the shell is 22 in. Let it be required to find the area of the segment to be braced.

According to the small table at the left, the value of d for a head ½ in. thick and a working pressure of 180 lb. is 2.98 in., which, for all practical purposes, may be taken as 3 in.

The radius of the boiler is $R = 27$ in. and $H = 22$ in. Therefore, $(R - d) = 27 - 3 = 24$ in. and $(H - d - 2) = 22 - 3 - 2 = 17$ in. In the main table locate 17 in the first column at the left and follow along the horizontal line to the column headed 24. At this point the value 573 appears, which indicates that the area of segment to be stayed is 573 square inches.

The Electrical Study Course—Putting Balancer Sets into Service on Three-Wire System

Deals with the speed regulation of balancer sets composed of compound machines, and with the factors affecting the size of machines to use. Also takes up the subject of starting sets preparatory to connecting load to them.

THE previous lesson brought us as far as a consideration of the elements that affect the speed regulation of a balancer set that consists of compound machines. The connections for such a set are shown in Fig. 1. The series fields H_1 and H_2 are connected in the manner which will cause the machines G_1 and G_2 to operate as differentially compounded motors. That is, when running as motors the direction of the current through the series field is such that the magnetization produced by it is in the opposite direction to that produced by the shunt field.

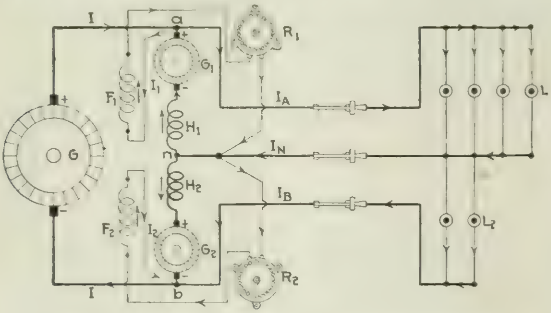


FIG. 1. CONNECTIONS FOR COMPOUND-WOUND BALANCER SET

It is to be noted that when connected as in Fig. 1 machine G_1 or G_2 will be a cumulatively compounded one when it runs as a generator. That is, when operating as a generator the magnetization due to the series-field current is in the same direction as that due to the shunt-field current. This is because the direction of the current in the armature, and consequently in the series field, reverses whenever the machine changes from motor to generator or vice versa, while the shunt-field current is always in the same direction. Consequently, we have a differentially compounded motor driving a cumulatively compounded generator, the two being connected in series across the generator G.

Making the same supposition in regard to the load as in the previous lesson—namely, that L_1 is larger than L_2—we know that G_2 must be the motor driving G_1 as the generator. Since G_2 is a differentially compounded motor, its speed will tend to increase as the load upon it is increased, since the effect of the load current through the series field is to reduce the excitation. However, as soon as it begins to increase in speed it drives G_1 faster, which increases the voltage of G_1, causing it to furnish a greater current and thereby increasing its voltage still more owing to the cumulative effect of the current through the series field. As the voltage across G_1 increases, that across G_2 must decrease, since it is the difference between the constant voltage maintained across *ab* by G and that across *an*.

Decreasing the voltage impressed upon a motor causes its speed to be reduced, consequently the accelerating action of the current in the series field is checked by the drop in voltage. The difference between this method and the one using shunt machines with interchanged fields, described in the last lesson, is that in this method the accelerating action is due to the increase of load on G_2, and the retarding action is due to the increase of voltage across G_1, whereas in the other method acceleration is due to decrease in voltage across G_1, and the retarding effect is due to the increase of load on G_2.

The size of the machines used in a balancer set depends upon the maximum value that it is expected the unbalanced load current will reach. If it is known that the amount of unbalancing will never be very great, small machines may be used for the service irrespective of what the total load on the system might be. On the other hand, if the unbalancing is likely to be very large, the capacity of the balancer machines must be greater. That is, there is no direct relation between the total load a three-wire system is called upon to take care of and the size of the balancer set that must be provided. Thus, a comparatively large system on which only a slight unbalancing could occur at any time would require a much smaller balancer set than a smaller system on which serious unbalancing had to be provided for.

The extreme case of unbalancing would be that in which all the lamps on one side or the other might be turned out. In such a case each balancer machine would have to be big enough to take care of half the full current of one side of the system, since under those conditions the current in the neutral would be the same as in the loaded outside wire, and, as shown in the previous lesson, the current in the neutral wire divides nearly equally between the two machines.

Balancer sets may run continuously for long periods of time, but there are of course occasions when they must be shut down, and means must therefore be provided for starting them up again when they are to be placed in service. We shall therefore give some consideration to the methods used.

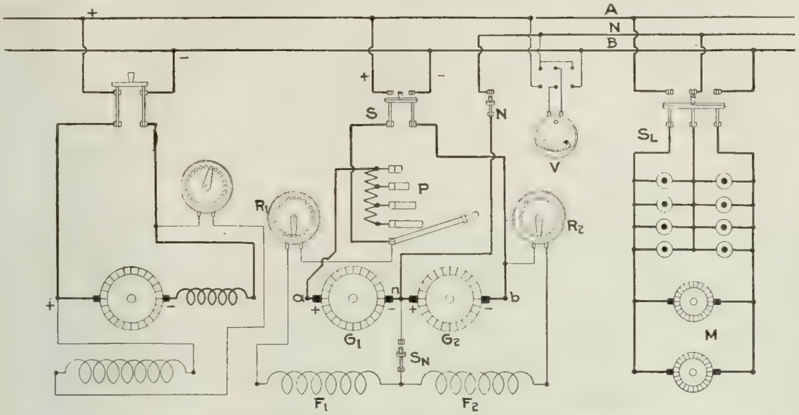


FIG. 2. SWITCHING SCHEME FOR BALANCER SET ON THREE-WIRE SYSTEM

Fig. 2 represents a simple arrangement. For the sake of clearness the machines G_1 and G_2 are shown of the shunt type and their fields F_1 and F_2 are shown each connected to its own machine instead of being interchanged. As shown, the two machines are connected in series to the starting switch *P*. The resistance of the field rheostats R_1 and R_2 is all cut out, and the switch S_N is opened, thus placing the field windings F_1 and F_2 in series without any connection to the neutral. It is necessary to do this for the reason that, for the polarity shown, the armature of G_2 when at rest would act as a short-circuit across its field F_2, causing the voltage across F_2 to be very small at the moment of starting and consequently impressing double normal voltage across F_1 and causing it to take twice normal current while practically no current flowed through F_2. By opening switch S_N the same current is made to flow through both F_1 and F_2, thus causing the excitation of the machines to be the same.

Besides adjusting R_1 and R_2 to zero and opening S_N, an inspection is made of switch S_L, to see that it is open. Switch *S* is then closed and the motors are started in the usual manner by means of the starting-switch *P*, at which time switch S_N is closed. The next step is to close the neutral switch *N;* then the voltages across G_1 and G_2 are tested by applying voltmeter *V* across *AN* and *NB*. If the machines are not found to have the same voltage, the excitation of the one showing the higher voltage is reduced by increasing the resistance in its field circuit. Thus, if the voltage of G_1 were found to be higher than that of G_2 the resistance of R_1 would be increased in order to reduce the current through F_1 and thus reduce the voltage of G_1, until the voltages across the two machines were the same. They would then be ready to have the load placed upon them, which would be done by closing switch S_L.

The connections for compound machines would be the same as those for shunt ones excepting that the series field would of course be connected as part of the armature circuit. The problem of the preceding lesson consisted of finding the values of the currents in the different parts of a three-wire system such as that in Fig. 1. The load consists of 100-watt and 110-volt lamps of which there are 800 in load L_1 and 600 in load L_2, and the generator *G* maintains 220 volts across *ab*. When running idle, the machines G_1 and G_2 draw 20 amperes. Since there are 800 lamps in L_1 each of which consumes 100 watts, the load on this side of the system is 800 × 100 = 80,000 watts. The voltage across each side being 110 volts, the current required for this load is $\frac{80,000}{110}$ = 727 amperes. Similarly, the load L_2 is equal to 600 × 100 = 60,000, and the current required by it is $\frac{60,000}{110}$ = 545 amperes. The total load on *G* is the sum of the lamp loads plus the balancer load. The latter is 20 amperes at 220 volts, or 20 × 220 = 4400 watts. The load on *G* is therefore 80,000 + 60,000 + 4400 = 144,400 watts and this divided by its voltage, namely, 220 volts, will give the current *I* in the mains, or $I = \frac{144,400}{220}$ = 656 amperes. From the preceding calculations we have I_A = 727 amperes and I_B = 545 amperes, from which $I_N = I_A - I_B$ = 727 — 545 = 182 amperes. Since I_A is 727 amperes and *I* is only 656 amperes, I_1 must be equal to 727 — 656 = 71 amperes in the direction from *n* to *a;* and since I_B is only 545 amperes, the current I_2 must be equal to $I - I_B$ = 656 — 545 = 111 amperes in the direction from *n* to *b*.

In Fig. 3 loads L_1 and L_2 are composed of lamps taking 120 amperes and 180 amperes respectively, and the load *M* consists of motors taking an aggregate of 230 amperes. The machines G_1 and G_2 take 10 amperes. What are the values and directions of currents *I*, I_A, I_B, I_N, I_1, and I_2? What would have to be the capacity of the machines G_1 and G_2 to take care of a completely unbalanced condition, if the system is operating at 110 to 220 volts, and the maximum lamp load across each side is 200 amperes?

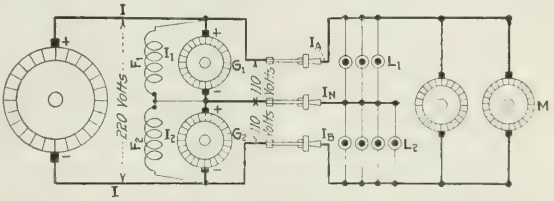


FIG. 3. CONNECTION FOR SHUNT-WOUND BALANCER SET

Chart for Finding the Factor of Evaporation

By G. H. SHEASLEY

IN CALCULATING steam-boiler performance it is necessary to find the factor of evaporation. To do away with computations it is desirable to use some sort of table or chart from which the required factor may be read direct for any given set of conditions. A chart for finding the factor of evaporation is shown in the illustration, and in preparing it an effort has been made to have it cover practically the entire range of conditions that are liable to be met with in practice. The chart shown can be used for either saturated or superheated steam. The factors shown are based on the values given in the steam tables of Marks and Davis.

The method of using the chart may best be illustrated by a couple of examples. Suppose that the factor of evaporation is to be found for the changing of water at 160 deg. F. into saturated steam at a pressure of 140 lb. gage, which is 155 lb. absolute. Locate the pressure of 155 lb. on the bottom scale and proceed vertically until the saturation curve is reached. Next, from this point on the saturation curve follow a horizontal line until the diagonal marked 160 deg. F. is reached. Then proceed vertically to the top of the chart, and the point thus located will correspond to 1.099, which is the factor of evaporation for the conditions assumed.

Next, suppose that the feed water has a temperature of 208 deg. F. and the steam has a pressure of 200 lb. gage and a superheat of 150 deg. F. A pressure of 200 lb. gage is about 215 lb. absolute. So, locate 215 lb. on the bottom scale of the diagram and follow it vertically to the curve marked 150 deg. F. Then proceed horizontally to the diagonal marked 210 deg. F., which is the nearest value to 208 deg. F. From this point on the diagonal, proceed vertically to the scale at the top, where the reading will be found to be 1.141, which is the factor of evaporation.

The total heat per pound of steam of any given condition may also be found from the chart. After finding the intersection of the vertical line from the value of the pressure and the curve representing saturation or degree of superheat, follow horizontally to the scale at the left of the chart, where the total heat will be indicated.

Charts for this purpose have been made from time to time, some being in the form of alignment charts while others employ a sliding scale. No special advantage is claimed for the chart over any other for the purpose, except that it is so designed as to cover a wide range of conditions and at the same time allow the size of the chart to be reduced to the minimum. Also, all scales are within the limits of the chart and so the use of a straight-edge is unnecessary in the reading of the desired result. Neither is a specially constructed base necessary, as in a chart employing one or more sliding scales.

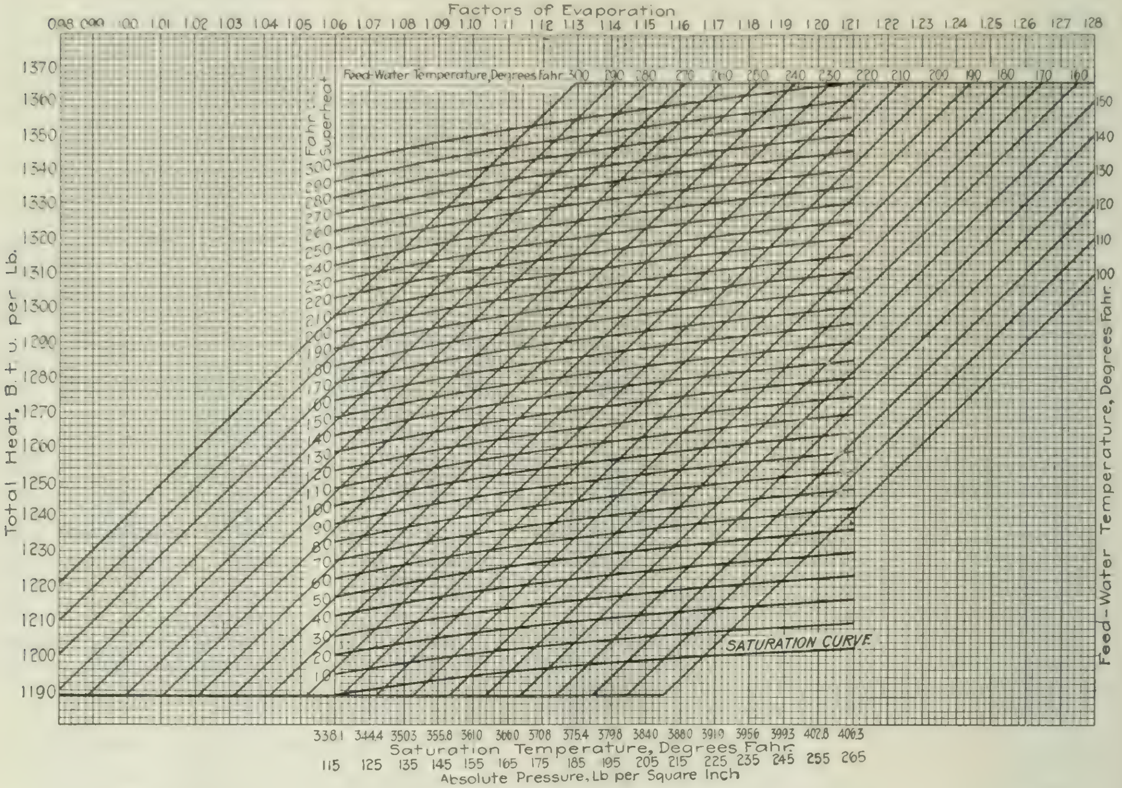


CHART FOR FINDING FACTOR OF EVAPORATION OF SATURATED OR SUPERHEATED STEAM

EDITORIALS

Improving the Qualities of American Marine Engineers

PERHAPS no one more profoundly appreciates the value of the training of marine engineers by the United States Shipping Board's schools than the older engineers who, at first, were demonstrably reluctant to approve the Board's plan for training men for American ships. Marine engineers, from the designers down to the third assistants, are notoriously conservative and tenaciously enmeshed in tradition. Many of the older operating men have not bothered with books or with keeping pace with the advancements in the art. With them, as things were done long ago they should be done today. Naturally, men of this character are inclined to resent the intrusion of the younger men, who were desirably technical if lacking the long years of experience of the older fellows.

A peculiar thing has happened. To shut out the younger or newer type of men for engineer officers of the merchant marine, the staid, conservative engineers, honestly believing they were protecting the service, attempted to "stiffen" the requirements of the United States Steamboat Inspection Service. With the intensive and comprehensive training given applicants by most of the schools of the Shipping Board, they are so well grounded in fundamentals that they quite easily go over paths on which the older, less technical men stumble. Experience is showing that stationary engineers, who have been forced by license legislation and encouraged by their trade organizations to study, make more rapid progress through the Board's schools than do the older type of marine men. But the latter are about to improve, they are agreeably coöperative, and the Shipping Board will doubtless give them every opportunity to meet the new conditions. The merchant marine of Great Britain does not suffer from this trouble as much as the American marine suffers, for the reason that there have long been well-conducted schools in England and Scotland which have been doing for the British seaman what the schools of the Shipping Board are doing for Americans. The service will be immeasurably improved, and every man in it will rejoice at the change. The service is being done as much for them as for the country that is dear to them.

The Skilled-Labor Outlook

POWER plants have been among the most acute sufferers from the labor conditions disjointed by the war. The traveler who observes and listens as he goes not infrequently hears bitter denunciation of the Administration's pre-war policies as the cause of the trying troubles through which those requiring labor have passed and still are passing.

The informed and honest mind will grant that there is a modicum of truth in the argument, but it is only a modicum of truth. The plain fact is that the nations, not alone armies, cannot turn belligerent and preserve the established routine of peace. Increased remuneration, within reason, is the incentive which promotes productive rate. War is precipitate and requires of a nation accelerated production, and it requires it forthwith. Labor would have had to be stimulated in 1914 or 1916 just as it was stimulated later when America awoke to her duty. The exigencies of the moment caused the unparalleled labor turnover, and by the same immutable social law it will force another turnover now that the crisis has ended overnight.

Extraordinarily high wages were for labor part of the spoils of war. Their continuation far into the period of adjustment or of peace would impose a ruinous burden. Their too sudden reduction would create a perilous psychological situation full of the virus of Bolshevism. And the peril of Bolshevism is real, even for America.

As regards the skilled-labor outlook engaged in power-plant work, a resumption to normal is making pleasing headway. The desirable labor is returning, less cocky than when it went away. The lure of other places has lost its punch, and the good men, once back on the old job, are content to stay. We find the plants of the country still in abnormal condition, but rapidly coming back to the stability of the days that seem so long ago.

The New Laboratories of the Bureau of Mines

THE Bureau of Mines is one of the noteworthy achievements in the progress of the relationship between technology and the Government. It is, however, peculiar that the Bureau is legally but a Government servant; that is, it is legally an advisory and technical bureau for use only by Government departments. Legally, it is not for the service of industry broadly. But Government departments require so much industrial information that no infractions of the law are made by the Bureau when it takes up the varied work which it performs and which is invaluable to the industries. We understand that this is not true of the Bureau of Standards; it is not so restricted.

But someone needs to enlarge the vision of Congress to the end that such a far-reaching technical branch of the Government as the Bureau of Mines may spread out to fields adjacent to those in which now it makes two blades of grass grow where but one grew before. Appropriations for the Bureau are woefully small. Programs laid out by the mechanical, chemical and mining divisions must be done with much the same niggardly caution with which the clerk, professional or other of the intermediate millions now buys a pair of shoes. Frugality is a virtue which the Bureau exercises. Some day the industries which benefit in such great measure from the work of the Bureau may give the substantial support that they should be called upon to give.

Elsewhere in this issue the new laboratories of the Bureau of Mines are described and profusely illustrated. From the article one will see that these laboratories are a great workshop. They are substantial evidence of the widening scope of the Bureau, in which the people of the country have an investment that perhaps pays higher dividends than are realized from any other equivalent appropriation.

The Passing of the Use of Carbon-Filament Lamps

WAR has left its effects, both beneficial and otherwise, upon every industry. In the field of illumination one of the most marked effects was a reduction of fifty per cent. in the sale of carbon-filament lamps during 1918 from that in 1917. This type of lamp has long since outlived its economical existence, therefore it must give way to the more efficient tungsten-filament type. When it is considered that the fifty-watt tungsten lamp will give three times as much illumination as the fifty-watt carbon lamp, and that the cost of the former is only about fifty per cent. greater than that of the latter, and that for the last five or six years one type has been just about as durable as the other, it is difficult to understand how a market could be found for twenty-four million carbon-filament lamps in this country in 1917.

When the tungsten lamp was introduced in 1907, its high efficiency soon made it apparent that with improvements in the filament to make it more substantial, this type of lamp was going to replace the carbon-filament type in a few years. However, the carbon lamp held its own until about 1914, when the sales dropped from approximately fifty-five to twenty-five millions. The supplying of these uneconomical lamps free to their customers by many of the central-station companies has doubtless had a marked effect in maintaining millions of them in use. As late as 1917 there were some seventy cities in the United States having a population of forty thousand each and over, aggregating a total of approximately eight million, five hundred thousand, where central-station companies were supplying carbon lamps free to their customers. This figure does not include those cases where carbon-filament lamps are supplied free and tungsten lamps sold at a reduced rate. How long this might be continued under normal conditions is hard to surmise, but under the stress of the abnormal conditions brought about by the war many of the central stations abandoned their free-renewal lamp service, and during 1918 a program for the elimination of all unnecessary types of carbon lamps was approved by the United States Fuel Administration. As a result the carbon-lamp sales dropped to less than twelve millions last year, with good prospects that this lamp will pass into disuse in the near future.

The cost of keeping twenty-four million carbon-filament lamps in service per year over the same number of tungsten lamps of equal candlepower is difficult to determine, but it has been estimated that it means the burning of over one million additional tons of coal, not to mention the loss in human productive capacity due to the poor quality of the illumination from carbon lamps. Even at this late day we are to be congratulated that such an important step has been taken to eliminate this unnecessary waste.

Labor and Mechanical Refinements in Power Stations

POWER-STATION economies have now but one chief road to lower production costs—namely, refinements. The quest for new types of prime movers ended with the steam turbine. Lower costs must now be sought by the more intense and scientific application of established operating principles and by broadening the field of utilization to build up the load factor. Both these entail much.

The production of modern power-station machinery demands a higher class of shop labor than in days gone by. The disjointed labor conditions caused by the war and the troubles experienced with the product of such labor as was available is sorry evidence of this truth. But it is in the power house where lies the greatest gap between mechanical progress and competent operative skill. The one has not, broadly, kept pace with the other. Increasing the load factor means greater continuity of service, a greater unit-time output for the station and its parts. Apart from complications in machinery, closer running clearances, high rates of heat transfer, higher pressures, temperatures and velocities, the load factor alone, as a time element, calls for constant vigilance and, when coupled with the foregoing factors, demands of the operating and maintenance crews a different appreciation of their responsibility, a higher accuracy of judgment, a more thoroughly technical training than necessary to successful operation some years ago.

The state of affairs is appreciated by those in responsible charge, as is evidenced by the educational courses of the National Electric Light Association, the very encouraging technical trend in the national and state conventions of the National Association of Stationary Engineers, and in other lesser bodies. But there should also be more systematic training of the men within the individual station, a more rapid discovery and more decisive disposition of misfits, a more careful study of the adequacy of remuneration of and progressive opportunities for the exceptionally apt worker—a merit system with meritorious rewards.

There was a time when many flouted the idea that a woman could perform mechanical operations, because, according to tradition, she could not even drive a nail straight. That ancient pleasantry received its deathblow in the same war as did Prussianism.

Many articles are received for publication that would be greatly increased in value if they were accompanied by either photographs or sketches. When sending in letters and articles for publication, do not forget the illustrations.

After July 1 there will probably be plenty of brass rails on the market. Engineers who have had difficulty in obtaining condenser tubes may view the future with hopefulness.

You cannot make an engineer out of a man by giving him an indicator any more than you can make a poet out of one by giving him a fountain pen.

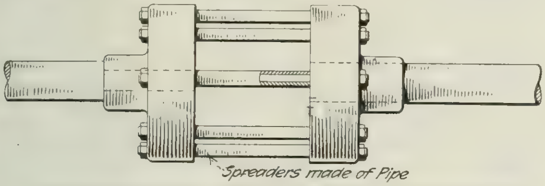
It is fortunate that the cause of world-wide liberty did not turn out as disappointing a failure as the so-called "Liberty" fuel.

Correspondence

Emergency Shaft Repair

Another way in which an emergency shaft repair such as that described in the issue of Jan. 7, page 24, could be made is shown in the illustration herewith.

First procure new coupling bolts longer than the original ones and an equal number of pieces of ¾-in. pipe cut to fit and to act as spreaders between the halves of the coupling. If the load on the shaft is heavy, it may be advisable to drill additional holes and use a larger number of bolts than were in the coupling originally.



HOW SPREADERS WERE APPLIED TO COUPLING

Schenectady, N. Y. PETER J. M. CLUTE.

Motor Suddenly Reversed

In the Jan. 21 issue of *Power* is given an experience of John R. Steeska where a motor suddenly stopped, reversed and ran in the opposite direction, which brings to mind a similar experience that I had shortly after entering the military service.

In the electrical laboratory at Clemson College, S. C., was a small direct-current generator which was used as an exciter for an alternator. The exciter was rated 250 watts at 110 volts and was compound-wound. One day we connected this machine up as a motor and, as luck would have it, got the series- and shunt-field windings in opposition. The machine would start and run satisfactorily until the starter arm was advanced to the farthest point, when it would slow down, reverse and continue to operate in the opposite direction. This was caused by the inrush of current at starting being sufficient to make the series field stronger than the shunt; the motor then started in a direction corresponding to the polarity of the series-field winding. As the machine came up to speed, the current through the armature and series winding decreased to a point where the shunt field became the stronger and reversed the polarity of the motor, causing it to stop and reverse its direction of rotation.

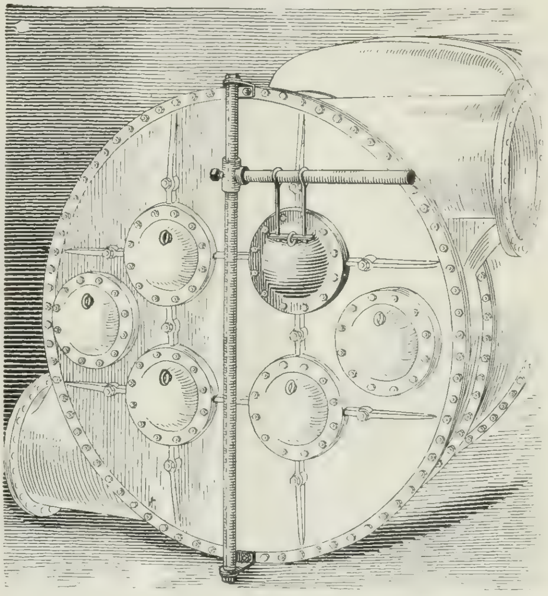
If Mr. Steeska's machine was compound-wound, it may be that it was differentially connected and when a heavy overload of short duration was thrown on, the series field became stronger than the shunt and caused the reversal. R. W. HERRING.

Camp Mills,
Long Island, N. Y.

[When a direct-current compound-wound generator is put into motor service either the shunt-field or series-field windings must be reversed to give the correct polarity to the windings for motor operation. Mr. Herring's experience is that of many others who attempt to operate a compound-wound generator as a motor without reversing one of the field windings.—Editor.]

Crane To Handle Condenser Manhole Plates

It is difficult for one man to remove the manhole plates of a large condenser. The illustration shows an easily made device for this purpose. Two angle brackets are fastened to the condenser shell by drilling through and tapping the holes or using bolts. A rod of the proper length is passed through a section of pipe cut long enough to reach from the top to the bottom bracket. A washer and nut are put at the top and at the bottom of the rod and the nuts are tightened, allowing the pipe just enough freedom to swing easily. A tee and a section of pipe, heavy enough to hold the condenser plate, form the arm of the crane. A setscrew in the back of the tee fastens it to the upright pipe at the desired height. Two eye-bolts on the swinging arm and a connecting piece put through the handle in the plate make it possible, after taking the weight on the crane, to remove and swing the plate to one side. Instead of the two eye-bolts a rod with a hook at the end can be used if desired.



HOME-MADE MANHOLE PLATE CRANE

Norristown, Penn. WILLIAM H. WATSON.

Unsymmetrical Indicator Diagrams

Again referring to the subject of unsymmetrical indicator diagrams, as answered by Mr. Lewis in the issue of Jan. 28, page 140, taking the diagram as shown and assuming 10 per cent. clearance of piston displacement and $\frac{9}{10}$ or $\frac{8}{10}$ piston travel as points of exhaust closure, I agree with the author that when the exhaust valve closes at $\frac{9}{10}$ stroke the compression pressure at full stroke will be double, and if the exhaust valve closes at $\frac{8}{10}$ stroke the compression pressure at full stroke will be three times as great as the exhaust pressure at the time of exhaust closure, but this is absolute pressure (temperature correction omitted).

Referring to Fig. 1, as that of a high-pressure cylinder and assuming that the absolute zero pressure is 15 lb. below atmospheric pressure and that the back pressure is 20 lb. gage, or 35 lb. absolute, if the exhaust valve closes at $\frac{9}{10}$ stroke with 35 lb. absolute pressure in the cylinder, then the full-stroke compression pressure would be 70 lb. absolute pressure, or 35 lb. effective compression pressure.

If the exhaust closes at $\frac{8}{10}$ stroke, there would be one-third the original volume at full stroke, or three times the original pressure "absolute," but only 70 lb. above the 35-lb. back-pressure line, which is only twice the effective back pressure when the exhaust closure takes place at $\frac{9}{10}$ stroke.

This same condition exists in the low-pressure cylinder, as shown in Fig. 2. Assuming the exhaust pressure to be atmospheric (or any other pressure that it might be), the full-stroke compression pressure with an exhaust closure at $\frac{8}{10}$ will be only twice as great "above the back or exhaust pressure" as when the exhaust closure takes place at $\frac{9}{10}$ stroke.

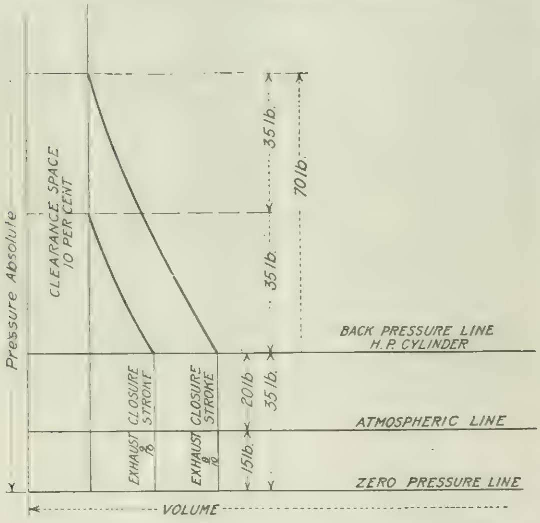

Pressure Absolute
CLEARANCE SPACE 10 PER CENT
35 lb.
70 lb.
35 lb.
BACK PRESSURE LINE H.P. CYLINDER
20 lb.
35 lb.
ATMOSPHERIC LINE
15 lb.
EXHAUST CLOSURE 8/10 STROKE
EXHAUST CLOSURE 9/10 STROKE
ZERO PRESSURE LINE
VOLUME

FIG. 1. COMPRESSION CURVES OF HIGH-PRESSURE CYLINDER

The nearer the actual indicator diagram approaches the theoretical diagram, or as Mr. Lewis puts it, "a picture in a book," the better will be the economy and the operation of the engine. I recall an instance where an engine attendant loosened the locknuts on the eccentric rod and screwed the rod out until the engine ran noiselessly. After he had caused two perfectly good head-end crosshead pin brasses to cut out and then complained that the brasses were no good, I was called upon to investigate the cause and by indicating the engine found that nearly all the work was being developed in the crank end of the cylinder.

I would like to see the actual indicator diagrams, one set with the compression shifted to one end of each cylinder as described by Mr. Lewis, and one set from the same one with the compression equally or nearly equally divided between both ends of each cylinder. I mean by actual cards taken with correct reducing rig. It may be that Mr. Lewis is fooling himself with an incorrect reducing apparatus.

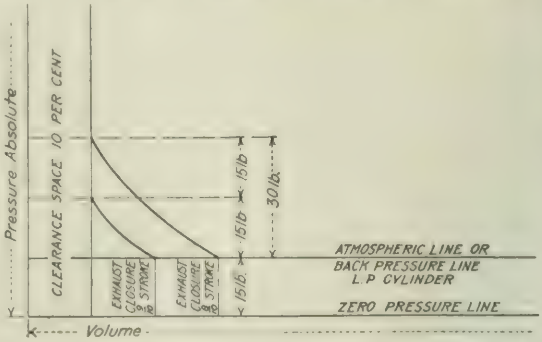

Pressure Absolute
CLEARANCE SPACE 10 PER CENT
15 lb.
30 lb.
15 lb.
ATMOSPHERIC LINE OR BACK PRESSURE LINE L.P. CYLINDER
EXHAUST CLOSURE 8/10 STROKE
EXHAUST CLOSURE 9/10 STROKE
15 lb.
ZERO PRESSURE LINE
Volume

FIG. 2. COMPRESSION CURVES OF LOW-PRESSURE CYLINDER

San Francisco, Calif. V. R. **Hughes.**

Overheating Hot Water Wasteful

In his letter on page 256 of the Feb. 18 issue Mr. Meinzer says, "There is no economy in drawing a quantity of hot water and then cooling it by the addition of cold water." Neither is there any waste, as there is no loss in mixing cold with hot water to obtain the desired temperature. The hotter the water from the domestic heater the less of it will be used to produce the proper temperature for lavatory purposes, etc., the actual B.t.u.'s used being practically the same per gallon for all ordinary temperatures of the hot-water supply.

The arrangement mentioned of placing steam pipes in kitchen sinks, etc., would hardly be in the interests of economy. A large quantity of steam could be wasted by unskillful handling by the kitchen help, and the steam valves would inevitably leak after having been in use a short time. A steam jet is not an economical water heater, particularly when the temperature of the liquid is near the boiling point, as considerable steam escapes to the atmosphere by being carried to the surface in the form of bubbles.

It is true that by carrying a high temperature in the hot-water mains the heat loss from the pipes is increased to some extent, but this loss would not be serious if the pipes were properly covered.

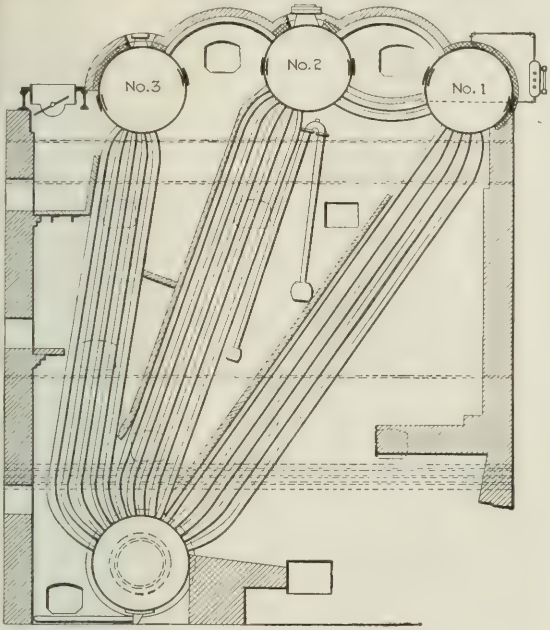
A temperature of 180 deg. at the heater will usually be found to be the most desirable—at any rate where there is a laundry or kitchen. Where water is required for lavatory purposes only, a temperature of about 130 deg. will usually be sufficient. D. F. **Grahame.**

Ottawa, Ont., Canada.

Different Boiler Water Levels

It would have been better if Mr. Regan, in his letter on page 786 in the issue of Nov. 29, 1918, had stated what kind of boilers were in use in the plant to which he referred, how the drums were placed, how the water column was piped and where the baffles were placed between the tubes.

An experience I had with a Stirling boiler a short time ago may clear up some points. The column was connected up as shown in the illustration, and the location of the fusible plug was at the center of the middle drum and about six inches above the bottom of the drum. The first pass of the gases is up the first bank of tubes under the first drum, then down the second bank and up to the stack. The water circulation is of course from the cooler to the warmer part of the boiler, and in this case it was from No. 3 drum, where the feed water also enters. Steam is drawn for the No. 2 drum.



WATER LIFTED IN NO. 1 DRUM

We start with two inches of water in the glass and a low fire. A hot fire would send the water up in the glass about four inches, and after starting the engine the water would go still higher. If the engine was shut down the water would drop back to the two-inch level and it would sometimes drop out of sight at the noon hour; but on starting up again it would go half way up the glass, sometimes more.

The reason is apparent, for No. 1 drum and bank of tubes receive the hottest gases and do the most work, and, with the rapid circulation, the water is forced into No. 1 drum, producing a higher level than in either of the other two drums. Some may say that taking steam from the middle drum would not cause the water to rise in No. 1 drum; but all the drums are connected at the top, and starting the engine simply takes steam from each as fast as made. It is a question whether there might not have been times when the plug was exposed during the time the engine was in operation. The remedy was to connect the bottom of the water column to the middle drum on a level shown by the dotted lines in No. 1 drum; the water level can then be kept wherever desired. This can be done by connecting into the middle head near the bottom.

I once had a similar boiler piped with the water column connected to the middle drum and the steam to No. 1 drum, and no trouble was experienced, although the boiler supplied a turbine carrying a variable railroad load. When the turbine was shut down, the water level would remain stationary.

I think if Mr. Regan would trace out the path of the water and gas circulation, he would find his case similar to mine. WILLARD E. MORSE.

Orange, Mass.

Abstracting Heat from Blowoff Tanks

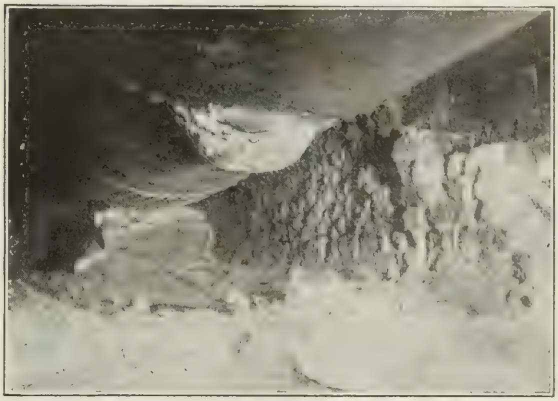
Drip and blowoff tanks containing hot water that cannot be utilized, should be equipped with inside coils of pipe through which water on its way to the house hot-water tanks and feed pumps can flow, thus absorbing the heat from these dirty drips and blowoffs, which would otherwise go to the sewer.

Brooklyn, N. Y. W. T. MEINZER.

Burning Fuel Oil in a Coal-Burning Furnace

The picture may interest readers of *Power* as illustrating the results that may occur through the application of oil fuel in a boiler setting that was originally designed to burn coal; that is provided the term "design" is applicable to a setting of this kind.

As a boiler inspector I warned the owner of this boiler some time previously that if oil was used it would be necessary to change the setting, so that the oil flame would not be driven up by the remains of what was once a bridge-wall. This warning was disregarded with the result shown.



BAG CAUSED BY BURNING FUEL OIL IN FURNACE DESIGNED FOR BURNING COAL

The bag on the boiler is down about 4½ in. and is cracked open at the bottom where the metal is drawn down to a knife-edge thinness. The shell plate is also cracked open at the rivets in the girth seam.

San Francisco, Calif. R. L. HEMINGWAY.

Carbon and Commutator Wear

As mentioned in the letter by R. E. Hellmund in the Feb. 4 issue of *Power*, there is need both among carbon manufacturers and designing engineers of electrical machinery for more definite data on how carbon wear is affected by current density, sparking voltage and peripheral speed. However, the effect of each of these characteristics on brush wear is influenced to such a great extent by other factors that exact determination is practically an impossibility.

Consider the effect of current density. The increased brush wear caused by increase in current density is due to the higher temperature so created at the brush face and the consequent more rapid disintegration of the carbon at that point. Any factor tending to further increase the temperature at the brush face will add to the rapidity of wear. Some of the things having this effect are: High coefficient of friction; higher contact drop than is needed for commutation, especially on machines of low voltage and high current capacity; contact drop too low for sparking voltage, permitting heavy currents to flow in the short-circuited coil; lack of carrying capacity or very high current density.

As mentioned by Mr. Hellmund, higher current densities are permissible where there is no sparking voltage than where there is. This is because the heating effect of commutation current is absent and higher load currents can be applied before the same temperature rise is attained.

PERMISSIBLE SPARKING VOLTAGE

Mr. Hellmund's statement that sparking voltages of 15 to 20 volts are permissible if the current density is low enough is open to question. Average volts per commutator segment may be as high as the figures named without difficulty being encountered. Or the reactance voltage may be that high and still be neutralized by interpole flux or fringing field within sufficiently close limits to secure good commutation. But the sparking voltage—that is, the resultant between the reactance voltage and the other electromotive forces generated within the coil undergoing commutation—should be less than the contact drop of positive plus negative brush to attain perfect commutation. Inasmuch as 3 volts is about the highest brush-contact drop obtainable, it will be seen that the sparking voltages mentioned would not be neutralized within 12 to 17 volts. Such a voltage would set up excessive currents in the short-circuited coils and result in rapid burning away of the brush faces even with no-load current whatever carried by the machine.

Commutator wear may be caused by the use of abrasive brushes. It may also result from the same mechanical or electrical causes that produce brush wear. Mechanical conditions of this nature are: Rough commutator due to poorly prepared surface; rough commutator caused by burning; vibration from any source such as the pound of a direct-connected engine, poor belt lacing, improper mounting, loose bearings or commutator out of true; high peripheral speed, causing brushes to chatter or creating an excessive temperature at the brush faces due to friction; type of brush-holder or angle of operation, resulting in the chattering of the brushes.

Electrical conditions causing rapid brush wear are: Sparking, from any cause whatever; glowing of brushes; pitting of brush faces.

Glowing results from excessive current density and may be local or may cover the entire contact end of the brush. Common causes are unequal collection of current by different brushes of the same polarity and very heavy short-circuit currents in the coils undergoing commutation, which, added to the load current, bring the temperature of the carbon at the face of the brush up to the glowing point.

Pitting may result from glowing in small spots on the brush face. It is also caused at times by particles of copper becoming attached to the brush face. This causes a heavy current to localize in a small area, disintegrating the carbon and forming a small crater in which the copper embeds itself.

RESISTANCE TO DISINTEGRATION OF BRUSHES

The source of brush wear from all electrical and some mechanical causes is disintegration of the carbon at the brush face due to the temperature attained at that point. There is considerable difference, however, in the ability of different forms of carbon to resist this disintegration. Graphite is much more refractory than amorphous carbon, consequently there is less wear on a graphite brush from a given degree of sparking than will occur with a coke brush. Even better than the brush made up from pure graphite, held together by a carbonized binder, is the electrographitic brush. This type of brush can be made much harder and stronger than the molded graphite brush, thus offering superior resistance to the mechanical causes of wear. In addition, the binding material in the electrographitic brush has been transformed into graphite and possesses high refractory properties, while the binder in a molded graphite brush is merely converted into coke during the baking process and consequently is more susceptible to disintegration under sparking and glowing.

It is unfortunate that it is not possible to accurately determine the influence on brush wear of the factors mentioned by Mr. Hellmund. It is possible, however, to obtain a great deal more data than are now available on certain other brush characteristics which have a pronounced influence on brush wear.

Contact drop should be studied under commutating conditions, since figures obtained on slip-ring tests are of doubtful value when applied to commutating service. Sparking voltage should be determined for each grade of brush under varying conditions of current density and peripheral speed. By sparking voltage is meant the resultant voltage in the coil undergoing commutation below which no visible sparking occurs.

Thermal conductivity should be studied as a guide to the amount of radiation or ventilation that must be provided to keep the temperature at the brush face below an injurious value. Finally, the refractory properties of various grades and the influence on these properties of the brush composition and the method of manufacture should be studied more carefully than has yet been done. By this means grades may be developed which are capable of meeting much higher current densities, sparking voltages and peripheral speeds than any which have been produced up to the present time.

Columbus, Ohio. WARREN C. KALB.

Inquiries of General Interest

Conversion of Pump into Air Compressor—For best results, what changes should be made in a single direct-acting steam pump to convert it into an air compressor? R. W. C.

Ordinarily, the water cylinders of pumps are provided with a liberal percentage of clearance volume, as it is advantageous to their operation and adds convenience in their design and construction. For compressing air efficiently there should be a minimum percentage of cylinder clearance, and conversion of a steam pump into an efficient air compressor would at least require replacement of the water cylinder by a properly designed air cylinder.

Selection of Boiler Capacity—What number of boiler horsepower should be installed for supplying steam to a 500 hp. engine? W. D.

A boiler horsepower is the equivalent evaporation per hour of 34.5 lb. of water from and at 212 deg. F., and the evaporative capacity of a boiler is assumed to be based on good firing, fair quality of fuel and good draft. The number of pounds of steam required for development by an engine of an indicated or an actual horsepower, varies with different types of engines from about 12 lb. to 50 lb. of steam per horsepower per hour according to the type of engine and the actual load. For most situations it is advisable to install at least 25 per cent. larger number of boiler horsepower capacity than the number of engine horsepower that is to be developed, in order to provide against temporary excessive demands for steam, poor grade of fuel and imperfect draft, and to have spare capacity for cleaning fires and for boiler inspection, cleaning and repairs.

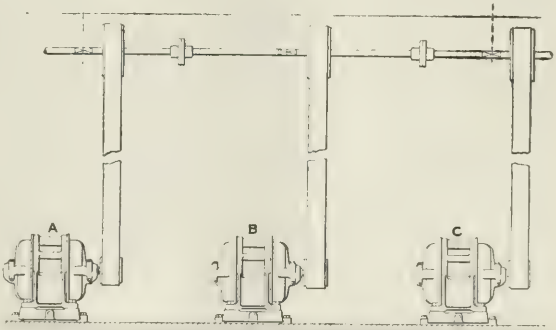
Making Hydrostatic-Pressure Test with Injector—It is desired to make a hydrostatic test of a boiler that is to carry a pressure of 110 lb. per sq.in. What should be the test pressure, and could such a test be made with an injector that is supplied with steam from another boiler carrying a pressure of 110 lb.? J. C.

It is customary to subject boilers to a hydrostatic-test pressure 50 per cent. greater than the proposed working pressure. Most good forms of feed-water injectors, when supplied with dry steam, are capable of forcing the water against pressures at least 50 per cent. greater than the pressure of the steam supply, and injectors are manufactured that obtain much higher test pressures. When an injector is used as a test pump, the safety valve of the boiler under test should be set at less than the test pressure, so the test pressure will not be exceeded. When the safety valve opens and the test gage indicates about 80 per cent. of the intended test pressure, the discharge of water from the safety valve should be gradually throttled, and the injector stopped immediately when the test pressure has been reached.

Unbalanced Load on Induction Motors—We have in our plant three 75-hp. induction motors driving a lineshaft, as shown in the figure. When motor A is carrying the entire friction load, the ammeter reads 47 amperes per terminal; when A and B motors are running, the ammeter on the former shows 42 amperes per phase, and when all three motors are driving the friction load, the ammeter on motor A shows 35 amperes. When all three motors are driving the full load on the lineshaft, motor A takes 135 amperes, motor B 85 amperes and motor C 75 amperes. The motors are operating on a two-phase 30-cycle 425-volt system. I would like to know why motor A takes more load than either of the other two machines and what may be done to balance the load between the different motors. Motor A operates at a higher temperature than motors B or C. G. A. B.

Since motor A is operating at a higher temperature than the others, it is apparent that the characteristics of the three motors are not the same and that motor A is taking more than its share of the load. When motor A is driving the friction load alone, it takes 47 amperes. The small reduction in this current as the other motors are added is due to two causes. As the mechanical load is reduced on an induction motor, its power factor is also reduced, consequently the current will not decrease in proportion to the load reduction; and the other cause for the small reduction of current in motor A is that this motor is taking more than its share of the load.

An arrangement where two or more motors are used to drive the same load cannot be expected to divide the load equally between the different motors, since it is not possible to design and build two machines that possess identically the same characteristics. Even if the machines had the same internal characteristics, the difference in the external conditions would in all probability affect the load division. The latter will be affected by the position of the rotor in the stator bore, which will be changed as the bearing wears; the voltage at the motors' terminals will change slightly with the location of the motors; the size of the pulley and the tension on the belt, if the machine is belt-driven; again, the resistance of the rotor may change by some of the connections between the end rings and bars becoming defective; if the motors are wound-rotor machines, the load characteristic of the machine will be affected considerably by the resistance of the brushes on the slip rings, the machine with the highest-resistance brushes taking the least load.



GROUP OF MOTORS BELTED TO LINESHAFT

If the machines are of the wound-rotor type, it may be possible to equalize the load between them by putting new brushes on motors B and C, having a lower resistance than the ones now in use, or putting higher-resistance brushes on motor A. In any case the load can be balanced up by slightly increasing the size of the pulleys on motors B and C or decreasing the size of the pulley on motor A, especially if the latter is made of wood or fiber. However, until there is no danger of one of the motors becoming overloaded, there is not any serious reason why the load should be balanced on the machines. On the other hand, if the load is no greater at any time than that given in the problem, there is no reason why, if the load is properly balanced, two of the motors cannot carry it and will then operate at a somewhat improved power factor over that obtained with the three machines.

All current readings should be made with the same instruments, or if different instruments are used on each motor, they should be checked "before and after" taking readings, to make sure that all instruments read alike.

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Fuel Administration and the Utility Plant*

By CHARLES BROSSMANN†

THERE are no restrictions on coal at present. The utility plant can use all it wishes—at the price, if it is agreeable to them. However, with so many utilities during the last year asking for surcharges, we find the main reason is increased operating expenses, with fuel as one of the chief factors, so that it is quite evident that the price of fuel is still of considerable importance. Granting this, some of the things found in utility-plant practice were peculiar. These conditions are not confined to municipally owned plants, but exist in private plants as well, although probably to a lesser degree.

It is of interest to note an encouraging news item from a paper only a short time ago, in which one large company withdrew its plea for a rate increase, stating that it had determined to see if it could overcome some of its excessive expenses through reduction on the price of coal and better operating conditions. This is a gleam of encouragement, and it is to be regretted that this stand was not taken more often, or at least an endeavor made to cut down expenses so that the surcharge asked need not have been so great.

There have been several means of reducing expenses in utility plants. These can be divided into two general classes—one by interconnection of utility and power plants, where in one case the larger plant will usually be more economical of operation and where the interconnection would result in saving fuel or labor or both—the other reducing operating expenses.

INVESTIGATING PROPOSED INTERCONNECTION PROJECTS

The mere fact that interconnection of a smaller and a larger plant could be made does not necessarily imply that there would be a saving. A number of such cases have been carefully investigated, and in some instances it has been found possible to save and in others the interconnection would show even a greater fuel consumption.

In investigating a proposed interconnection, the practice was made to get all possible details of operation, and in numerous cases actual tests were conducted on the plants in question, so that the possible fuel saving could be determined. The Fuel Administration was not concerned in the dollars and cents saving—the main object was the conservation of fuel; but with the information determined, it became an easy matter for the plants concerned to find out what the saving in money would be. One thing that stood out very plainly in some plants was the lack of engineering foresight used, and emphasis should be placed on the fearlessness with which some public officials had determined offhand engineering problems that a competent and trained engineer might spend several weeks in investigating and figuring in order to get the best results.

Another conspicuous feature in some cases was the method of operating without records of any kind, without any effort to determine costs and without any knowledge of the results as compared with other plants. In one instance the superintendent of a light plant was not allowed in the power house and could only look after the street equipment. The power house was looked after by one of the public officials, and changes were being made that at that time seemed absolutely unnecessary. At one place the designer was abused for putting in a certain recording device, and yet the device was not operating, although it was of fine standard equipment; no records were kept and the question of rate increase was up at the time. Just think of a plant using anywhere from sixteen to twenty pounds of coal per kilowatt (See Fig. 1) and selling current to the water department for 30 per cent. less than it cost to make it! Here the current was generated by a small generator operated by a slide-valve engine running with a back pressure and then pumping water with a motor and centrifugal pump, while right in the plant stood a compound-pumping engine with which the over-all steam rate for pumping would have been considerably less than with the centrifugal pump. In this plant a saving of 2000 tons of coal a year was possible.

Fig. 1 gives the increased cost per kilowatt-hour in this small plant, showing the rise of 1½-cent coal cost to almost 3¾ cents per kilowatt-hour sold. It also shows that the coal used ranged from 11½ to 17 lb. per kilowatt-hour generated, or 14 to 21 lb. per kilowatt-hour sold. There is no reason why this plant should not have operated at from 12 to 14 lb. per kilowatt-hour which would have been bad enough, and the inefficiency in operation is almost mainly attributable to both management and methods of operation.

What encouragement is there to an operating engineer who is ordered to discontinue keeping records? Is it any wonder that such a plant should be using almost twice as much coal as necessary? On questioning the fireman, he said he had worked there only three days, and I believed him, for I counted 27 shovelfuls of coal going under that boiler at one firing.

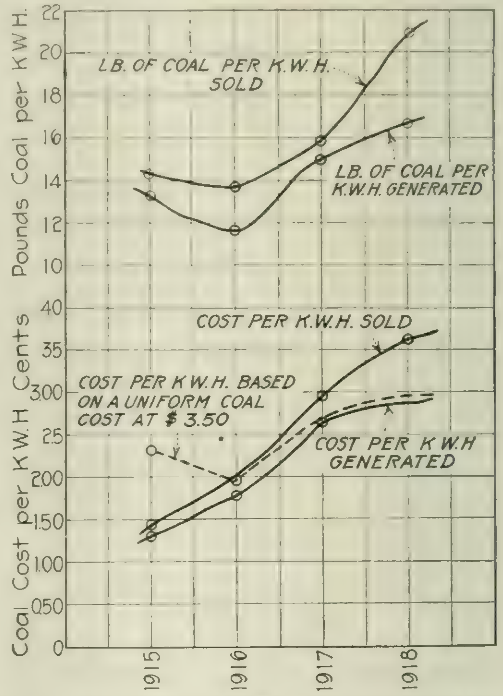

FIG. 1. SHOWING INCREASED COST PER KILOWATT-HOUR IN SMALL PLANT

In another case careful tests were made on two plants considering interconnection—a municipal light and water plant and a much larger private utility. Loads of both plants were carefully taken and actual coal tests made under several different conditions, and it was found that a saving of almost a thousand tons of coal a year could be made. It is worthy of comment that the superintendent had already cut down his coal consumption on the electric end to a considerable degree. The main reason for this further saving was in the difference of the size and loading of the machines in the two plants, the large plant having almost three times the capacity of the smaller one. In this case the smaller plant was operating at only one-quarter load and was using for this work about six thousand pounds of coal to make the run during the night. A test operated on the larger plant, pulling the additional load with its own, showed that only 1000 lb. additional coal was used to do this same work.

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*Read before the Indiana Engineering Society.

†Consulting engineer, power and utility plants, U. S. Fuel Administration.

Fig. 2 shows the average coal for the station duty run of over 60-hours test with this load. The amount chargeable to running the small-plant street lights is figured as follows:

	Kw.-Hr.	Coal
With street lights	2,920	21,000 lb.
Without street lights	2,040	20,000 lb.
Street lights	880	1,000 lb.

It will thus be seen that to carry the 880 kilowatt-hours for street lights it required 1000 lb. of coal, or 1.12 lb. per kilowatt-hour, which would be the figure to use in comparing with the small plant's coal consumption, in order to show the saving.

It is of interest to note that the average curve for this 60-hour run coincides almost exactly with the load, with or without street lights. This result was due to the fact that the night load was poor and this additional load gave a much better load factor. It should be added, however, that even in this larger plant, no scales were used for weighing coal until the Fuel Administration asked for this test.

In this case the question of electrical pumping was not considered, as no coal saving would have resulted, because the municipal plant was pumping its water with a compound Corliss condensing engine and was using less coal than would have been used by the larger plant to pump electrically.

Electric Pumps Not Always the Most Economical

There seems to be the idea, among a good many central-station men that any electric pump can be operated more economically than any steam pump. This is not always the case. Of course, where labor is saved, that will sometimes even offset what might be lost on coal. In one case where the matter of pumping the water of the municipal plant had been agitated, the proposed interconnecting company had a fair-sized plant, but it was found that to furnish current for pumping, as compared to the city's steam pump, would have resulted in an actual loss of fuel, although it was rather hard to convince the company officials of this fact. This was apparently because they did not realize that a high-duty crank-and-flywheel condensing pumping engine had almost as low a water rate as their large electric unit. However, they were finally, though reluctantly, convinced.

In another instance of interconnection on water plants, it was found and recommended that electrically driven centrifugal pumps, as compared with the old noncondensing duplex, would result in a saving of fuel and labor that would pay for the investment in a little over four years. In this case the city went ahead and made arrangements to change over.

From the foregoing it will be seen that there is only one safe thing to do—investigate each case carefully.

It must not be thought that all the plants examined are horrible examples. Some of the medium-sized plants found in the state were operating at as low as 4½ lb. of coal per kilowatt. In one of these plants the manager has well-kept records of all loads and conditions, and he could give on a moment's notice any information regarding the plant operation. It is rather interesting to know that the most of the plants in which no records are kept and which have no means of determining what is being done are uneconomical. In one particular boiler plant they had the scales, coal cars and water meter, but the fireman only went through the motion of weighing and taking the water records, and put them down so that they looked "about right."

In another instance one operating engineer said he had been "jumped" by the councilman because he did not get the cars of coal off the switch fast enough; they had no place to store it and had to pay demurrage. "The other engineer burned it faster than you do, and I do not see why you can't do it," was the argument.

In one plant, in which the records were fairly well kept, it was found that they were using from 6½ to 7½ lb. of coal per kilowatt-hour generated, and this looked fairly good on the face of it. An analysis of the boiler-flue gases showed only about 4 to 6 per cent. CO_2. It is quite evident that with such a showing there is no reason why the coal per kilowatt-hour should not be further reduced by better boiler economy, and this is being accomplished in this particular plant. Some of the plants visited had the necessary equipment to take the proper tests, but claimed that they were losing money, although they were not trying to better conditions as they should have done.

Analysis of the trouble in many of these plants shows that a large part of their losses is caused by improper boiler-room operation and by not keeping proper records or by not properly analyzing them. There have been many plants where from 10 to 20 and even 50 per cent. saving in coal could be made simply by changes in operating methods. This is one of the important lessons of which advantage should be taken.

Another most important thing is the method in which new equipment is purchased, without any analysis of operating loads and conditions and on the hit-and-miss theory. This trouble comes more from the municipal plants, although a number of such cases were found in other places. I make the assertion that thousands of dollars are wasted every year in municipalities, by improper purchasing without expert engineering advice and without careful engineering analysis of the true conditions.

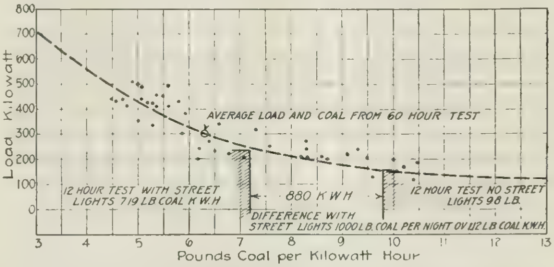

FIG. 2. COAL CONSUMPTION WITH HAND-FIRED WATER-TUBE BOILERS; 60-HOUR TEST

The important lessons shown from the Fuel Administration work are:

That too little attention is paid to the proper and economical operation of the plant, as pertaining to the boiler room, as the greater proportion of loss of the plant seems to take place in the manufacture of the steam.

That interconnection in numerous cases would be advisable. Owing to the character of the equipment combined with the methods of operation, economical central stations have power available, and advantage should be taken of the possibility of interconnection so that uneconomical plants can be placed on a sound basis.

Another important reason is found in the method of purchasing new equipment and making additions to plants without any regard to the adaptability of the units purchased. Greater attention should be given to getting the exact working conditions of the plant and to providing economical machinery and purchasing new plant equipment.

I believe that the time has been reached as regards public utility plants or any kind of power plant, when strict attention must be given to proper design and purchase and more accurate methods of operation used; and if such things were looked after there would be much less trouble and fewer failures in such plants.

West Virginia License Bills

A number of bills seeking the same object—the licensing of stationary engineers—were introduced in the West Virginia legislature during the regular session that just ended, but none passed either house. Under the terms of at least one of the bills the owner of a boiler or stationary engine of over 10 hp. could not have operated his own engine, but would have had to hire a duly licensed engineer to run it for him.

Central Station Heating

By JOHN C. WHITE

Abstract of Technical Paper 191, Bureau of Mines, dealing with central-station heating; its economic features with reference to community service. In this abstract it is chiefly costs that are dealt with.

IT IS interesting to note that although many of the early companies charged a rate of only 20c. a sq.ft. (selling steam on the basis of square foot of radiation) for a season of seven or eight months, the fuel cost of energizing such radiation for a period of only six months (180 twenty-four-hour days) with an over-all efficiency of 50 per cent. in generation and transmission, steam at atmospheric pressure and a room temperature of 70 deg. F., would be from 10c. to 15c. with coal at $1 a ton. As few places get their coal at that price, it is easy to see why these heating companies failed. Many electric companies claim a cost of less than 1c. per kw.-hr. at the switchboard; the public, however, except a few large consumers, pays three to ten times that amount for what it uses. Steam heating can never carry such an excess as that, but there must be a margin for operation, distribution, overhead costs and profit. An attempt will be made in the following analysis to determine what difference exists between the cost of central-station service and of private heating to cover those items.

It has already been shown that the average fuel cost of supplying radiation under the conditions named will be about 10c. to 15c. a sq.ft. for a season of eight months with coal at $1 a ton. The cost can be readily computed with coal at any other price. From a series of tests at the engineering experiment station of the University of Illinois,[1] the plant efficiencies for such equipment with the fuels named were as follows:

PLANT EFFICIENCIES FOR FIVE FUELS

Fuel	Average Efficiency per cent
Illinois coal	48.86
Pocahontas coal	50.20
Anthracite coal	54.00
Gashouse coke	59.63
Solvay coke	61.73

The efficiencies given for Illinois coal are no doubt somewhat higher than will be maintained in practice by the average householder for an entire season. Based on the relative average heating values of the fuels named and with the efficiencies given, the prices at which the cost of heat would be equalized to the consumer are as follows:

DATA ON FOUR TYPES OF COALS

Fuel.	B.t.u. per Lb. as Fired, Average	Heat absorbed Total Value, Per Cent. Efficiency	Cost per Million B.t.u., Cents	Prices at Which Values Equalize
Illinois Coal	12,000	5,863	8.53	$1.00
Pocahontas coal	14,750	7,400	6.75	1.26
Anthracite	12,700	6,858	7.28	1.17
Coke	12,000	7,200	7.00	1.22

Thus it appears that with Illinois coal at $1 per ton we could afford to pay $1.26 for Pocahontas, $1.17 for anthracite and $1.22 for coke. The Illinois coal would therefore be in demand if it were not for other considerations than the cost of the heat. Some cities have smoke ordinances that make it nearly, if not quite, impossible for householders to burn Illinois coal. It also requires more labor to keep up the fires, remove ashes and clinkers and keep the heating surfaces free from soot. All things considered, Pocahontas coal, anthracite and coke are in demand at one and one-half to three times the cost of Illinois coal.

These differences represent charges against dirt, smoke and excess labor. In other words, they are a contribution to cleanliness and convenience. Taking the Illinois coal at $1 a ton, with a heat value of 12,000 B.t.u. and 49 per cent. average efficiency, the cost of energizing a square foot of radiation for 180 twenty-four-hour days will be slightly higher than for the central station mentioned, at which the over-all efficiency of generation and distribution was taken at 50 per cent. The fuel costs for the heat are therefore about the same, whether furnished by the private plant or from a central station with the same coal at the same price.

However, there are these differences. The central station can work at a higher sustained efficiency, it can produce electric current as a byproduct with only a small loss of heat generated, and it eliminates all of the objectionable features of a private plant.

VALUE OF CENTRAL-STATION SERVICE

The development of equipment and methods of operation in the boiler room of the modern power plant leave little to be accomplished there. Soft coal may be had under contract in Wisconsin at prices ranging from $2.50 to $3.50 a ton on track. It can be burned at an over-all efficiency of more than 70 per cent. and the product is heat with steam as the medium of transmission. Served in this manner through a distribution system, the heat has a value equivalent to the total cost of all items included in the operation of a private plant plus a considerable allowance for greater convenience and perfect cleanliness, and it should be so estimated in all computations on which costs and rates are based. Whether or not it is exhaust steam in whole or in part has no bearing on the case; any allowance in that direction should affect the price of current and not the cost or the value of the steam. The steam should be considered the prime requisite, with any output of incidentally derived current as the byproduct; it will then stand or fall on its own merits, which is the only substantial measurement of its value. The reasons on which this argument is based will be given later.

PRICE OF CLEANLINESS

As regards the generation and transmission costs and margins, with coal at $3 a ton and an over-all efficiency in the plant of 70 per cent. the steam can be delivered at a fuel cost of approximately 30c. a sq.ft. of radiation served. This allows 20 per cent. for loss in transmission, a figure considerably higher than that found in practice, as evidenced by a report in Bulletin 40[2] of the Bureau of Mines, where this loss is given as 4 to 12 per cent. The same coal will cost the private user about $4 a ton delivered at his premises, and his fuel cost for the same amount of heat will therefore be not less than 40c. But he still has the smoke, dirt and labor inseparable from the use of soft coal in such equipment as he uses.

If the problem be viewed from another angle, the cost of evaporating a given quantity of water in the large public-service plant as against the small private plant may furnish a better basis for comparison. With Illinois coal at $1 a ton the fuel cost of evaporating 1000 lb. of water (generating 1000 lb. of steam) should not exceed 7c., and in a well-designed and carefully operated plant may be as low as 6c. The other costs will increase this figure to about 10c., and with coal at $3 a ton the total cost will be about 25c. The private consumer cannot evaporate the water any more cheaply, even with coal at the same price, and as he will have to pay more for his coal, the cost to him of evaporation will be more. Furthermore, when he requires only a little heat the efficiencies drop very low and the losses are correspondingly great.

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[1] Snodgrass, J. M. Fuel tests with house-heating boilers: Bull. 31, Univ. Illinois Eng. Exp. Sta. 1909, 108 pp.

[2] Randall, D. T., and Weeks, H. W. The smokeless combustion of coal in boiler furnaces, with a chapter on central heating plants. 1912. pp. 181-182.

In the estimate of the cost of supplying 1 sq.ft. of radiation for 180 days, a rate of emission of 2.5 B.t.u. per sq.ft. of surface and per degree difference of temperature per hour was used. This rate shows that 1,500,000 B.t.u. will be required to energize 1 sq.ft. of radiation for the 180-day period. In evaporating 1000 lb. of water there will be a heat transfer of approximately 1,000,000 B.t.u., at a cost of 25c. with coal at $3 per ton. From these figures it evidently will cost 38c. to 40c. to evaporate the water for each square foot of radiation supplied. To this figure must be added all investment, operation and other charges on the plant and distribution system. These can only be approximated in a general estimate, but they will probably equal the fuel cost, thus bringing the total up to 75c. or 80c. a square foot a season. The reader should bear in mind that in the computations made on the quantity of heat emitted the radiation was assumed to be active for the entire period. This will not necessarily hold in practice, and less heat will be required than the amount charged in this discussion. It makes little difference, however, as the lessening will be about the same amount whether the radiation system is heated privately or from a public-service main.

Rates for Steam

From schedules of rates in 28 cities of 25,000 to 40,000 inhabitants, covering many of the Middle States and ranging in latitude from Michigan and New York to Georgia and Alabama, the highest minimum is $1.50 per 1000 lb. of steam at Peoria, Ill., and the lowest for maximum consumption is $0.3105, at St. Joseph, Mo. The lowest minimum consumption rate is 54c. at Penn Yan and Geneva, N. Y., and the rate at these points for maximum consumption is 46.35c. The average minimum and maximum rates for the 28 cities, on quantities of 4000 lb. or less and 300,000 lb. or more per month, are 76.40c. and 45.33c. respectively.

Although a study of these rates shows lack of uniformity in the methods of their deduction, the averages given confirm in general the costs established herein for furnishing 1000 lb. of steam. In about half of the schedules mentioned there is a demand charge of $3 a month minimum on all buildings having a capacity of 25,000 cu.ft. of space or less, and 12c. per 1000 cu.ft. on all buildings having more than 25,000 cubic feet.

Thus far exhaust steam has not been considered, because there is no difference between it and live steam at the same pressure, and any exhaust steam that may become available for distribution costs just as much and it is worth just as much for heating as though a part of its original energy had not been converted into useful work. In a combined plant the product resulting from such conversion—usually electric current—should be considered the byproduct.

Where the heating load is large enough to entirely submerge the power load, there will be no peaks in the boiler room through variations in the latter. The power requirements may vary from zero to maximum and the firemen will not know it unless someone tells them or they consult the records. When the engines are exhausting their maximum into the heating system, the reducing valves will automatically cut the supply of live steam to the required amount; when the power load is a minimum, they will open and supply live steam to meet the requirements.

Fuel Conservation in Connecticut

In order not to lose the impetus toward fuel economy gained under the stress of war conditions, manufacturers, power-plant owners, engineers and insurance interests in Connecticut are concerning themselves with a continuance of the conservation work begun last year in the power and boiler plants of the state, with every prospect that further gains will be secured during 1919. The fuel-conservation work in Connecticut typifies that done in many other parts of the United States under the guiding hand of the National Fuel Administration.

What was known in Connecticut as the Myers plan was elaborated and perfected in conjunction with other conservation committees and engineers and was finally adopted and promulgated by the United States Fuel Administration at Washington as the national plan for coal conservation in power plants, dating from May 1, 1918. The purpose of this plan was to reduce fuel waste in power-plant operation, not through expensive and extensive installation of more efficient apparatus, but by a more intelligent and careful use of the existing equipment. To accomplish this it was proposed to first ascertain by questionnaires how each plant complied with certain well-recognized standards in its operation and maintenance, and by a system of rating to force on the attention of the plant owner or responsible manager the wasteful conditions through which his plant failed of a higher score.

That there might be a strong incentive for improvement on the part of all, it was to be the announced intention that the relative rating of plants would influence the Fuel Administration's allotment of coal should a shortage occur. The plan further included a program of education through bulletins and other publications, lectures, meetings of plant owners, of engineers and firemen, to arouse an interest in and to maintain a constant effort for coal saving. The administration of this campaign in each state was to be in the hands of an engineer experienced in power-plant matters, and who, with his staff of workers, should be a part of the Conservation Division of the Fuel Administration. Mr. Corson, secretary of the Hartford Steam Boiler Inspection and Insurance Company, was appointed administrative engineer for Connecticut on June 17, 1918.

As Mr. Corson was a volunteer worker and could devote but a part of his time to this service, he had been authorized to secure as his assistant an engineer who would devote his entire time and effort to the work and would be compensated by a salary from the Fuel Administration. George H. Sharpe, a consulting engineer of the firm of Westcott & Mapes, Inc., of New Haven, influenced by a patriotic desire to be of service in the country's emergency, offered himself. Mr. Sharpe had all the qualifications required for the position and was accordingly nominated for appointment as Deputy Administrative Engineer for Connecticut. On July 22 he took up the duties of that position.

By the first of August the questionnaires filled out by the owners began flowing into the office, at first a few each day, but gradually increasing until the volunteer force of examiners was nearly swamped. Each questionnaire had to be examined and its answers marked and the plant rated and classified. For this work Prof. A. E. Knowlton, of Trinity College, Clarence C. Perry, of the Hartford Steam Boiler Inspection and Insurance Co. and William Ferguson and J. P. Calderwood, of the Travelers Indemnity Co., volunteered their services and gave constantly of their time and effort. When a questionnaire was valued, the owner of the plant was advised of the mark received by a form letter which showed him the effect of his rating of each item of his report. It thus became apparent to him in what features his plant was below standard. He was urged to give attention to them that he might secure a higher rating on the questionnaire that was to be returned by the inspector.

All together 1805 sets of questionnaires were mailed. Because of an imperfect mailing list, duplicates were sent to some plants and some questionnaires went to plants that used coal only for heating boilers of smaller size than those which it was the intention to rate. Instructions from Washington limited investigation to power plants and to heating plants of over 150 hp. capacity. Reports were received from 1467 plants, of which 918 were power plants or large-sized heating plants that had used during 1917 2,895,324 tons of coal. Of these, 562 plants, representing 2,104,759 tons of coal used in 1917, had been inspected and rerated when activities were halted by instructions received from the United States Fuel Administration under date of Dec. 11, 1918. Power plant owners received recommendations and suggestions in a spirit of cordial cooperation. Those who received high rating were evidently proud of it. Those who fell below a fair standard showed their eagerness to improve conditions. Many visited the administrative engineer's office personally to consult regarding plant features or operating practices that would prevent waste, and fuel-administration engineers made many special visits to plants by invitation of their owners to give advice on the prope combustion of fuel.

SUBSTITUTION OF OTHER COALS FOR ANTHRACITE

In addition to the work of the administration and carrying on the national program for conservation in power plants, Mr. Corson's department endeavored to coöperate generally with the Connecticut Fuel Administration and to help by engineering advice, investigations, etc., in any matter that would conserve coal. In the early fall, especially, the scarcity of domestic sizes of anthracite coal made it essential that consumers who could do so should substitute bituminous or buckwheat coal. Mr. Sharpe and other engineers throughout the state spent much time with great success in teaching anthracite users how to use these other coals. In this way the department contributed greatly to an improvement of the anthracite situation in Connecticut.

The Light and Power Division of the United States Fuel Administration at Washington asked Mr. Corson's office to coöperate in efforts to substitute power from efficient public-service plants for that produced less economically. This could not be done without a clear knowledge of the available public-service power in the state and the definite location of its lines of distribution. Accordingly, Prof. A. E. Knowlton, who was also consulting engineer for the Connecticut Public Utilities Commission, undertook a general survey of the power and lighting plants of the state. His investigation was made in conjunction with E. Irvin Rudd, engineer of that commission, during the month of August and resulted in the accumulation of valuable data.

INAUGURATION OF CONTESTS FOR COAL ECONOMY

In November, at the suggestion of Vice-President Samuel Ferguson of the Hartford Electric Light Co., the department invited a number of the larger public power plants of the state to join in a coal-economy contest. Three plants—the Hartford Electric Light Co., Hartford, The Connecticut Light and Power Co., Waterbury, and the Stamford Gas and Electric Co., Stamford—were interested and agreed to the competition. Each contestant paid an entrance fee of $5 per power-house employee. The basis of the contest was the percentage of improvement in coal burned per kilowatt-hour in a two weeks' run over a standard fixed for each plant from its experience for the previous fourteen months. The entrance fees were to be distributed as prizes to the power-house employees of the winning plants. The first contest began at 7 a.m., Nov. 11, and closed at 7 a.m., Nov. 24. It was won by the Hartford Electric Light Co. A second contest, based on the improvement in coal per kilowatt-hour over the average attained in the first contest, was arranged. This contest began on Dec. 2 and ended on Dec. 16. It resulted in the award of first prize to the Connecticut Light and Power Co., of Waterbury. A third contest had been arranged, but was called off when it was announced that the activities of the administrative engineer's department were to terminate. These contests evidenced clearly the wonderful results that may be secured under the stimulus of competition.

After the closing out of the engineering work in connection with the conservation division of the Connecticut Fuel Administration, Mr. Corson received from various power users and manufacturers in the state suggestions that the efforts on behalf of economical operation should be in some manner continued. The Manufacturers Association of Connecticut, Inc., wrote to the Hartford Steam Boiler Inspection and Insurance Co., expressing its interest in continued conservation work. Mr. Corson did not lose interest in the subject after relinquishing his duties as administrative engineer to the Fuel Administration, but expressed his desire that the economies gained might be continued and increased, pointing out that the industries of Connecticut as well as of the whole country will need every efficient practice in order to meet the broad world competition to be expected. The suggestion was made recently that the boiler-insurance companies establish a fuel-engineering inspection service, and in a bulletin dated Feb. 1, the Hartford Steam Boiler Inspection and Insurance Co. announced to its policy holders in Connecticut that it stands ready to assist them in this work. The company's engineering force is placed at the disposal of the policy holders in Connecticut as they may need it for the following purposes:

To advise and instruct concerning the use of draft gages, CO_2 apparatus, meters and other devices which may have been installed under the urgings of the Administrative Engineer; to instruct in proper methods of firing the different grades and qualities of fuel now being supplied; to investigate thoroughly plant conditions in order to point out where wastes are occurring; and to provide general supervision of plant operation. For advice and suggestions which are given entirely by correspondence no charge will be made; but when it is necessary for one of the company's engineers to visit a plant, a moderate charge will be made.

Connecticut power plants have been using about 3,000,000 tons of coal per year. The records of the distribution of coal show that 19/35 of the 1917 supply was sufficient for nine months' demand in the current coal year. On this basis the coal year ending Apr. 1, 1919, will in Connecticut require only 25/35 of the coal consumed in the state during the year ended Apr. 1, 1918. The department of the Administrative Engineer for Connecticut feels that its activities are entitled to much of the credit for this condition.

Hydro-Electric Power Bill

The hydro-electric power bill introduced by Senator Coalter early in the regular session of the West Virginia legislature never was reported from the Judiciary Committee of the Senate, to which it was referred after being favorably reported by the Finance Committee of that body. Just before final adjournment a Senate resolution was adopted asking Governor Cornwell to include the measure in his call for a special session which is to be held in March. It is doubtful, however, if the bill will be included in the call, since it is the desire of the governor to limit the legislature to the consideration of as few measures as possible.

The Swiss journal *Die Elektro-Industrie* gives particulars of a process for removing the temper from hardened steel. The piece to be softened is placed on a plate of iron at red heat and covered by a plate of cold iron. After the whole has cooled the piece of steel, whatever was its previous quality and degree of hardness, is detempered completely, and can easily be worked, without its quality having undergone any change by, for example, decarburization. The method is specially applicable to the unhardening of tools, more particularly punches and dies. Tests have given excellent results, and the method has the advantage that shaped pieces of steel do not show any shrinkage after treatment.

The Shawinigan Water and Power Co. has recently completed the longest transmission-line span in the world. The span is carried on steel towers 60 ft. square by 350 ft. high and crosses the St. Lawrence River about 20 miles from Three Rivers. A center span of 4801 ft. in length and two anchor spans, one 951 ft. and another 571 ft. in length, are used, making the total length of the crossing 6323 ft. Three galvanized-steel cables each $1\frac{3}{8}$ in. in diameter make up the span. The total weight of each cable is approximately 30,000 pounds.

During the eight weeks ending Feb. 22, the United States Employment Service received 1,090,124 applications from men and women for jobs. Of this number 930,029 were referred to opportunities and 679,513 were reported placed in employment.

New Publications

INVENTOR'S MANUAL—HOW TO MAKE A PATENT PAY.—By George M. Hopkins. Second Edition, Revised and Enlarged. Published by The Norman W. Henley Publishing Co., New York City. Cloth; 133 pages; 5 x 7½ in. Price, $1.25.

The object of this book is to give the inventor and patentee some hints on patents generally, together with a few methods of bringing them to public notice. It is a book which, according to the author, contains a quarter of a century of the experience of a successful inventor, together with notes based on the experiences of many other inventors. The book not only gives instructions to inventors regarding the taking out of patent papers and disposing of them, but calls attention and gives caution as to pitfalls to those who are not acquainted as to the methods of procedure when obtaining a patent.

Personals

W. C. Kalb, formerly brush engineer with the National Carbon Co., of Cleveland, Ohio, is now with the Corliss Carbon Co., of Bradford, Penn.

J. E. Whittlesey, formerly connected with the Heine Boiler Co., is now sales manager of the Joseph L. Skeldon Engineering Co., of Cleveland, Ohio.

Howard C. Thayer has resigned as field mechanical engineer of the 100,000-kw. power plant of the United States Nitrate Plant No. 2, at Muscle Shoals, Ala., and is now the New York representative of the Baker-Dunbar-Allen Co.

C. W. Johnson, who was formerly chief inspector of works and later general superintendent of the Westinghouse Electric and Manufacturing Co., has been appointed assistant manager of works. Mr. Johnson has been with the company 12 years.

J. R. Lowe, who is well known in steam engineering circles in the South, has been appointed representative of the Midwest Engine Co., of Anderson, Ind., at its New Orleans (La.) office, and will handle the pump, oil engine and turbine business of the company in that section.

Hartley Le H. Smith, formerly chief of the testing bureau of the Brooklyn Rapid Transit system, is now in charge of the steam-engineering department of the New England Power Co., Worcester, Mass. Mr. Smith was connected with the Brooklyn Co. for more than 16 years.

Captain Edward E. Ashley, Jr., for many years consulting mechanical and electrical engineer for Starrett and Van Vleck, architects, of New York City, has resigned his position in the United States Air Service to accept an appointment as sales engineer of the Mercury Manufacturing Co., of Chicago.

Capt. George Sykes, R. A. F., who has been in this country nearly four years, attached to the British War Mission in a commercial capacity, sails for Europe in May. He has joined Messrs. Dutilh-Smith McMillan Co., an international house, as London manager of its engineering and railroad departments. His New York address is 50 Broad St., and his London office is Central Buildings, Totehill St., Westminster. He will be very glad to see his American friends at his London address.

Engineering Affairs

The American Association of Engineers, New York Chapter, will hold a meeting on the evening of Mar. 28, at the Hotel McAlpin. C. E. Drayer, the national secretary, will address the meeting.

Miscellaneous News

The Taylor Society will open a permanent office in the Engineering Societies' Building, 29 West 39th St., New York, on Apr. 1. The activities of the society will be conducted from this office by Dr. Harlow S. Person, who assumes the title of managing director. Dr. Person has been president of the Taylor Society for the past few years. He is director of the Amos Tuck School of Administration and Finance, Dartmouth College, Hanover, N. H., and professor of organization and management with that institution. He has severed his connection with the Tuck School and will devote his entire time to the affairs of the Taylor Society on assuming office.

The United States Civil Service Commission announces that thirty first-class boiler makers are urgently needed at the United States Navy Yard at Norfolk, Va. Pay ranges from $5.36 to $6.40 for eight hours. Permanent employment is assured. Thirty days' leave with full pay is granted at the expiration of the first year of service and for each month thereafter two and a half days' leave is allowed with full pay. When overtime is necessary, time and a half is allowed for all time in excess of eight hours. The Navy Department has authorized the commission to furnish transportation to qualified men from point of departure to Norfolk, if the men will agree to work for at least six months. United States citizens only will be considered. Full apprenticeship and good physical condition necessary. Application Form No. 1800 is required, which should be fully executed and filed with the Civil Service Commission at Washington, D. C. This form can be secured either from the commission's office or from one of its field representatives. They are located in all of the larger cities of the United States.

Business Items

The Dayton-Dick Co. of Quincy, Ill., has changed its name to the Dayton-Dowd Co. The change was made owing to changes in organization. Capital has been doubled and the business placed under the control of those immediately interested. Facilities are greatly extended.

Trade Catalogs

The Metal and Thermit Corp., New York City, has issued a very attractive large map calendar, which shows the new railroad time zones in the United States that went into effect Jan. 1 of this year.

Columbia Recording Thermometers. Schaeffer & Budenberg, Brooklyn, N. Y. Catalog No. 300. Pages 61, 7¾ x 10¼ in.; attractively illustrated. A thorough and informative treatise on this type of instrument, which is for the accurate recording of all temperatures not exceeding 1000 deg. F.

The Jointless Fire Brick Co., Kingsbury and Clay Sts., Chicago, Ill., has just issued a 36-page instruction book on boiler-furnace linings, which contains useful and practical information on the installation of one-piece firebrick furnace linings. How to install and how to care for such linings are included in the contents.

The Jeffrey Type A Swing Hammer Shredder. The Jeffrey Manufacturing Co., Columbus, Ohio. Catalog No. 245. Pages 24, 6 x 9 in. In addition to a complete description, illustrated, of this type of shredder, this catalog shows typical arrangements of Jeffrey elevating and conveying equipments used in connection with same for handling the various materials.

Modern Methods of Ash Disposal is the title of a new catalog issued by the American Steam Conveyor Corp. This 160-page book is a treatise on the subject of ash handling. The first part is a comprehensive study of ash conveying equipment, and practically every type of conveyor is listed, the advantages and objections of each being enumerated. A large part of the book is devoted to a description of the company's ash conveyor and each of the patented steam fittings is described and illustrated. An interesting article shows the manner of application of the steam conveyor to boilers and stokers of various makes and a large number of diagrams clarify the discussion. Typical installations of steam conveyors are also described and illustrated. This catalog will not be given out indiscriminately, but copies will be given to engineers or plant owners supplying the following information: Present method of ash handling; number, type and horsepower of boilers; average steam pressure.

New Construction

PROPOSED WORK

Mass., Fall River—The city plans to build a new pumping station and dam. Estimated cost, $150,000.

Conn., Bridgeport—St. Michael's Polish congregation, 310 Sterling St., will install a steam heating plant in the school which it plans to build. Total estimated cost, $125,000.

R. I., Providence—The city will receive bids about May for the construction of a 2-story central heating plant. Estimated cost, $50,000. J. H. Gainer, Mayor.

N. Y., Brooklyn—The Cushman Baking Co., 44 Manhattan Ave., will install a steam heating plant in the 3-story, 60 x 100 ft. bakery which it plans to build on Nostrand Ave. and Malbone St. Total estimated cost, $125,000. Slee & Bryson, 154 Montague St., Arch.

N. Y., Brooklyn—Lehn & Fink, 129 William St., New York City, will install a steam heating plant in the 8-story, 40 x 100 ft. factory which it plans to build on Irving and Columbia St. Buchman & Kahn, 56 West 45th St., New York City, Arch.

N. Y. Huntington Park (Huntington P. O.)—A. Heckscher, 50 East 42nd St., New York City, will install a steam heating plant in the 1-story, 44 x 113 ft. museum which it plans to build here. Total estimated cost, $100,000. Maynicke & Franke, 25 East 26th St., New York City, Arch.

N. Y., Lockport—The Lockport Hydraulic Race Co. is receiving bids for the construction of a hydro-electric power plant and industrial building. L. H. Kunhardt, Ch. Engr.

N. Y., Long Island City—P. S. Karper & Bros., 68 West 34th St., New York City, will install a steam heating plant in the 6-story, 135 x 489 ft. factory which they plan to build on Jackson Ave. between Hulst and Harold Ave. Total estimated cost, $750,000. Ballinger & Perrot, 1328 Broadway, New York City, Arch.

N. Y., New York—The Stalwart Realty Co., c/o Ames & Co., 26 West 31st St., will install a steam heating plant in the 2-story, 100 x 171 ft. garage which it plans to build on Lenox Ave. between 110th and 111th Sts. Total estimated cost, $200,000. B. W. Levitan, 7 West 45th St., Arch. New West Side Garage Corp., lessee.

N. Y., Springwater—The Springwater Electric Light Co., Inc., has applied to the New York State Public Service Commission, Capitol, Albany, for permission to construct an electric plant here.

N. Y., Watertown—The New York Air Brake Co., Starbuck Ave., Northern New York Utilities Inc., Light & Power Bldg., J. B Wise, 401 Mill St., and associates, plan to incorporate the Beebee Island Corporation to develop power here. Plans include the construction of a power house, new concrete dam, flumes tailrace, the installation of 7500-hp. generating units, etc. Estimated cost, $500,000.

N. Y., Watertown—The Northern New York Utilities, Inc., Light & Power Bldg., will receive bids until Mar. 20 for the construction of a 1-story addition to the existing generating plant at Effley Falls, consisting of a 30 x 38 ft. power house, etc. J. B. Taylor, Pres. Noted Mar. 11.

N. Y., Watertown—The Watertown Bay Machine Co. has taken over the Eayer Electric Co.'s shop and will build additions and improvements to same for its own use. Estimated cost, $10,000. (The company will be interested to hear from power plant and transmission dealers.)

N. J., Newark—The American Oil & Supply Co., 52 Lafayette St., will install electric motors, pumping equipment, boiler apparatus, etc., in the factory which it plans to build at 238 Wilson Ave. Estimated cost of equipment, $25,000. P. B. Taylor, 31 Clinton St., Engr.

N. J., New Brunswick—The Eastern Potash Co., 120 Broadway, New York City, will install a steam heating plant in the potash plant which it will build. Total estimated cost, $2,000,000.

Penn., Bethlehem—The Travelers Tire Co., Travelers Bldg., Philadelphia, will install steam heating system, boiler and engine in the 2-story, 80 x 250 ft. factory which it plans to build near the Reading R.R. here. Total estimated cost, $250,000. J. O. Hunt, 114 North Montgomery St., Trenton, N. J., Arch.

Penn., Philadelphia—The Department of Public Works, City Hall, will install a heating system in the 1-story comfort building.

ets. which it plans to build at [illegible] Island Park. Total estimated cost, $[illegible]000. R. F. White, Pennsylvania Bldg., Arch.

S. C., North Charleston—The General Asbestos & Rubber Co. plans to build a [illegible]-kw. power plant. Estimated cost, $[illegible]. Lockwood Greene, Healey Bldg., Atlanta, Ga., Engr.

La., New Orleans—The city will install laundry unit, steam heating equipment, etc., in the 3-story hospital which it plans to build on [illegible] and Carr Ave. Total estimated cost, $[illegible]. E. A. Christy, City Hall, Arch.

Tenn., Memphis—The Southern Motor Co., [illegible] Monroe Ave., is in the market for a direct connected lathe, 16 or 18 in. swing with 8 to 10 ft. bed with motor either single or three phase, 220 volt a.c.

Ky., Henderson—The Henderson Cotton Mills having plans prepared for a [illegible]-kw. steam power plant. A steam heating plant will be installed in same. Estimated cost, $300,000. Lockwood Greene, Healey Bldg., Atlanta, Ga., Engr.

Ohio, Cincinnati—The Home Financing Co., c/o G. R. Bishop, 1209 Union Commercial Bank Bldg., will install a steam heating plant in the 8-story warehouse and terminal which it plans to build on Smith and Mill St. Total estimated cost, $3,000,000. A. M. Allen Co., 1900 Euclid Ave., Cleveland, Engr.

Ohio, Cleveland—The Board of Education, East 6th St. and Rockwell Ave., will install a steam heating plant in the 1-story addition to the school building which it plans to build on Warner Rd. Total estimated cost, $100,000. W. R. McCornack, East 6th St. and Rockwell Ave., Arch.

Ohio, Cleveland—The Cleveland Federal Reserve Bank, Williamson Bldg., will install a steam heating system in the 10 or 12-story, 150 x 200 ft. bank and office building which it plans to build on East 6th St. and Superior Ave. Estimated cost, $1,550,000.

Ohio, Cleveland—The Commercial Warehouse Co., c/o T. Knight, 250 The Arcade, plans to install a steam heating plant in the 10-story warehouse which it plans to build on Abbey Ave. Total estimated cost, $1,500,000. Fulton & Taylor, 631 Hippodrome Annex, Arch.

Ohio, Cleveland—Cowell & Hubbard, East 6th St. and Euclid Ave., will install a steam heating plant in the 2-story, 80 x 200 ft. commercial building which it plans to build on Euclid Ave. and 13th St. Total estimated cost, $300,000. Walker & Weeks, 1900 Euclid Ave., Arch.

Ohio, Cleveland—Paul Bros. Co., Citizens Bldg., will install a steam heating plant in the 3-story, 99 x 133 ft. salesroom which it plans to build on East 18th St. near Euclid Ave. Total estimated cost, $115,000. W. S. Ferguson, 1900 Euclid Ave., Engr.

Ind., Vincennes—The Indiana Power & Water Co., Bloomfield, plans to improve its plant, to supply power and light to the Illinois oil fields to the west of Vincennes. Estimated cost, $150,000.

Mich., Detroit—The Morgan & Wright Tire Co., foot of Bellevue St., has awarded the contract for the construction of a 7-story, 140 x 215 ft. warehouse, to Bryant & Detweiler Co., 2336 Dime Bank Bldg. A steam heating plant and two electric boilers will be installed in same. Total estimated cost, $700,000.

Mich., Highland Park (Detroit P. O.)—The city will install two 150-hp. high pressure boilers, pumps and laundry equipment in the 4-story hospital which it plans to build. Total estimated cost, $300,000. Meyer J. Sturm, 114 South Michigan Ave., Chicago, Arch.

Mich., Marine City—The Banner Salt Co. plans to build a 1-story, 50 x 100 ft. power house. F. F. Van Tuyl, 1112 Union Trust Bldg., Detroit, Engr.

Mich., Ypsilanti—The City Council recommended that the city sink new well, install 12 new hydrants, and new pumping machinery with electric auxiliary, etc. Estimated cost, $32,000. W. R. Caldwell, City Engr.

Ill., Chicago—The Blackwood Hotel Co., Clarendon and Windsor Ave., will install a low pressure gravity heating system in the 9-story, 56 x 96 ft. hotel which it plans to build here. Total estimated cost, $250,000. J. A. Taggert, 108 South La Salle St., Arch.

Wis., Milwaukee—A. Kuenseimann, 450 Mitchell Ave., will install a refrigerating system in the 1-story, 140 x 160 ft. market building which he plans to build on Mitchell and 8th Ave. Total estimated cost, $175,000. W. G. Herbst, Arch.

Iowa, Marshalltown—The city plans an election Mar. 31 to vote on a $100,000 bond issue for the construction of an electrical plant large enough to furnish light and power for commercial purposes. O. A. Rosengren, City Clk.

Minn., Slayton—The Slayton Power Co. plans to enlarge its power plant here. F. H. Eddy, Supt.

Neb., Chadron—The Chadron Electric Co. plans to build an electric light plant to supply the city with commercial current.

N. D., Fargo—The city plans election Apr. 1 to vote on $150,000 bonds for the construction of a light plant. F. L. Anders, City Engr.

N. D., Jamestown—The city plans election Apr. 7 to vote on bonds for the construction of light and power plant.

Okla., Stillwater—The city plans to install electric light and power plant machinery to increase its capacity. Estimated cost, $30,000.

Okla., Woodward—The city voted $30,000 bond issue for the installation of electric light and water-works plant machinery. Noted Feb. 11.

Ore., Eugene—The Eugene Fruit Growers' Association plans to build a cold storage and green apple packing plant, adjoining its cannery here.

Cal., San Diego—Olmsted & Gillelen, Engrs., 1112 Hollingsworth Bldg., Los Angeles, submitted report to city on sewage disposal plant. Plans include the installation of small pumping station to cost $32,500 and pumps at 32nd St. plant, $4000. Total estimated cost, $606,500. A. H. Wright, City Clk.

N. B., Lake Edward—The Department of Public Works, Ottawa, Ont., will soon award the contract for building a power house here. R. C. Wright, c/o Dept. of Pub. Wks., Ottawa, Arch.

Que., Three Rivers—The North Shore Power Co., Power Bldg., is receiving bids for the construction of an electric light station. Estimated cost, from $12,000 to $15,000. W. B. Baptist, Mgr.

Ont., Kingston—The Department of Public Works, Ottawa, will install a gravity steam heating system and two boilers, 60 in. diam. x 16 ft. long in the group of buildings which it plans to build at the Royal Military Hospital here. Total estimated cost, $400,000. R. C. Wright, c/o Dept. of Pub. Wks., Arch.

Ont., Port Arthur—The Ontario Hydro-Electric Comn., Toronto, plans to build a 1 story, 100 x 250 ft. power plant on the Nipigon River, Cameron Falls, near here. Estimated cost, $6,000,000.

Ont., Sydenham—The Department of Public Works, Ottawa, will receive bids until Mar. 21 for altering and building additions to military hospital here, same to be converted into power house, etc. Estimated cost, $75,000. R. C. Wright, c/o Dept. Pub. Wks., Arch.

Sask., Bounty—The village plans to build an electric light plant. G. A. Heron, Secy. Treas.

Sask., Broderick—The village plans to install an electric light plant. J. E. Alderson, Secy. Treas.

B. C., Squamish—The Department of Railways, Victoria, will soon award the contract for building dam, intake water supply system, hydro-electric power plants, transmission and lighting system, here. Estimated cost, $50,000. A. E. Procter, Victoria, Engr.

B. C., Vancouver—The Mainland Engineering Co., 422 Railway St., plans to construct a 54 x 125 ft. boiler and blacksmith shop, in connection with the foundry buildings which it plans to build. Total estimated cost, $70,000. Gardiner & Mercer, 827 Birks Bldg., Arch.

CONTRACTS AWARDED

Mass., Middletown—The Commissioners of Essex County have awarded the contract for the construction of a 1 and 2-story, 40 x 600 ft. hospital here, to C. E. Currier Co., 10 High St., Boston. Plans include the installation of power plant. Total estimated cost, $500,000.

Mich., Battle Creek—Nichols & Shepard has awarded the contract for the construction of a 2-story boiler plant, to Westinghouse, Church & Kerr, 37 Wall St., New York City. A steam heating system will be installed in same. Total estimated cost, $120,000.

Mich., Detroit—The Detroit Edison Co., David Whitney Bldg., has awarded the contract for building a 70 x 110 ft. addition to the central heating plant on Congress St., to A. A. Albrecht & Co., 1130 Penobscot Bldg.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8 05@8 35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net ton	$2 05@2 75	$2 80@3 20
Philadelphia, gross tons	4 15@4 90	5 00@5 45
New York, gross tons	4 50@5 25	5 35@5 80
Alongside Boston (water coal) gross ton	6 00@6 85	6 90@7 80

Pocahontas and New River are quoted at $4 70@5 25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7 20@8 60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5 95	$7 80	Pea	4 80	6 55
Egg	5 85	7 70	Buckwheat	3 40	5 15
Stove	6 10	7 95	Rice	2 90	4 65
Chestnut	6 20	8 05	Barley	2 40	4 15

Bituminous

	Spot	Contract
South Forks	$2 90@$3 50	$3 10@$3 50
Cambria County (good grades)	2 80@3 10	2 95@3 10
Clearfield County	2 65@2 95	
Reynoldsville.......	2.65@2 95	2 85@3 00
Quemahoning	2 85@3 10	2 95@3 10
Somerset County (best grades)	2 80@2 95	2 95@3 10
Somerset County (poorer grades)	2 50@2 75	2 75@2 95
Western Maryland	2 50@2 75	2 65@2 85
Fairmont	2 00@2 35	2 35@2 50
Latrobe	2 25@2 40	
Greensburg	2 35@2 40	
Westmoreland	2 60@2 75	2 65@2 75
Westmoreland run-of-mine	2 40@2 65	2 40@2 65

Quotations at the upper ports for both bituminous and anthracite are 5c higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5 95	$7 30	Buckwheat	$3 40	$4 45
Egg	5 85	7 20	Rice	2 90	3 80
Stove	6 10	7 45	Boiler	2 70	3 70
Nut	6 20	7 55	Barley	2 40	3 30
Pea	4 80	6 05	Culm	! 25	2 15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2 75	$3 25
Mine-run............	2 35@$2 50	3.00
Screenings	2 05	2 75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam.	$2 45	$2 75	$2 40
Black Creek and Cahaba	3 45	3 75	3 05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith.....	....	5 25	

Domestic quotations, slightly increased, are as follows:

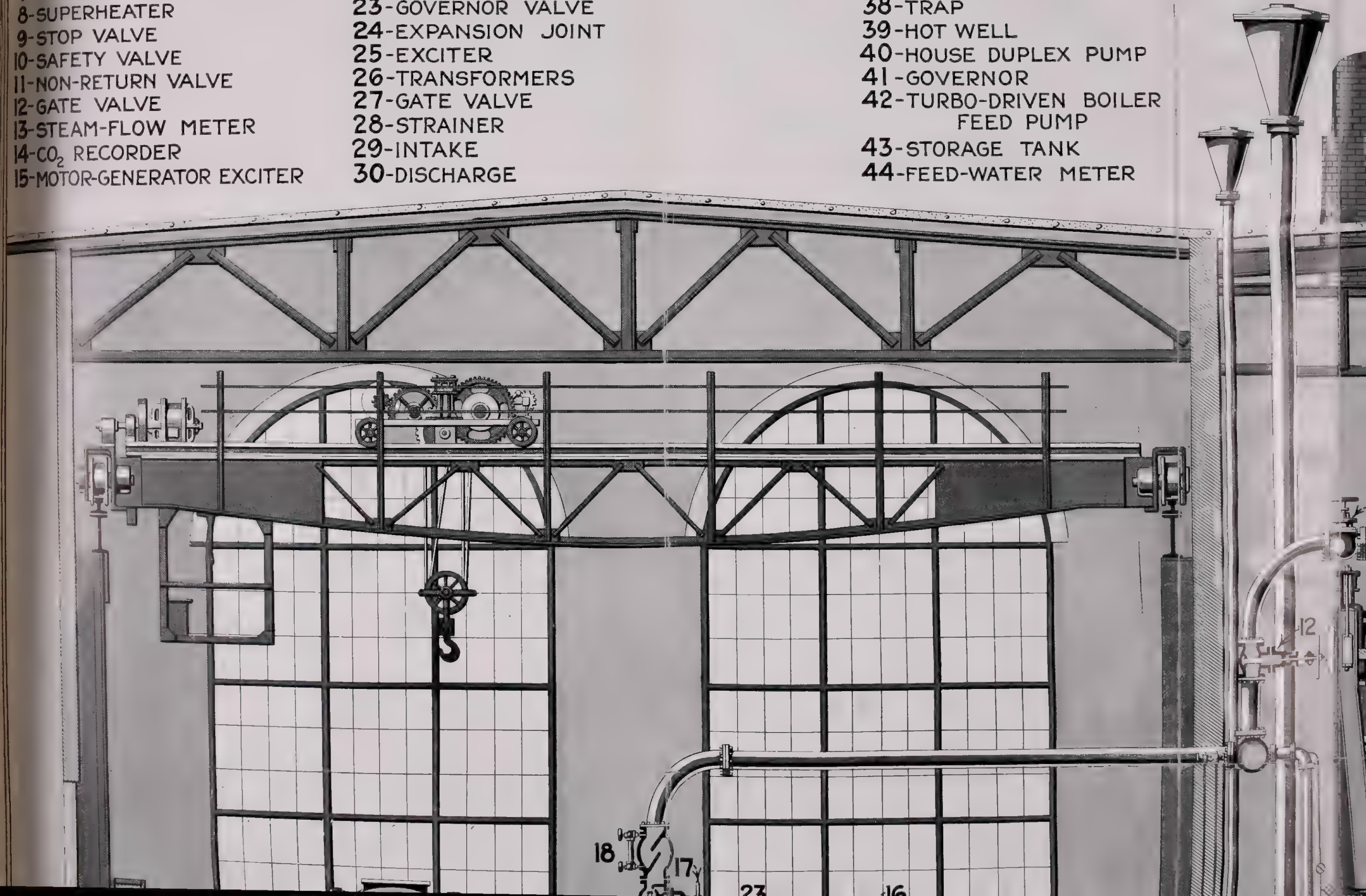
	Lump and Nut
Black Creek and Cahaba............	$4 50
Corona	3 75
Jagger...........................	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

	Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2 75		
Williamson County Prepared sizes, lump, egg, nut	$2 55	$2 55	$1 90@2 25
Mine-run	2 20	2 20	1 60@1 70
Screenings	2 05	2 05	95@1 10
3-in. lump..........	....	2.30	
2-in. lump..........	....	....	1 75@1 90

Williamson-Franklin rate to St. Louis is $1 10; other rates 92½c.

1-WATER COLUMN
2-COAL SCALE
3-FEED-WATER REGULATOR
4-RECORDING DRAFT GAGE
5-DAMPER REGULATOR
6-SOOT BLOWERS
7-STOKER
8-SUPERHEATER
9-STOP VALVE
10-SAFETY VALVE
11-NON-RETURN VALVE
12-GATE VALVE
13-STEAM-FLOW METER
14-CO$_2$ RECORDER
15-MOTOR-GENERATOR EXCITER
16-GOVERNOR
17-THROTTLE VALVE
18-SEPARATOR
19-GAGES
20-STEAM-CHEST THROTTLE VALVE WHEEL
21-BACK-PRESSURE VALVE
22-STEAM CHEST
23-GOVERNOR VALVE
24-EXPANSION JOINT
25-EXCITER
26-TRANSFORMERS
27-GATE VALVE
28-STRAINER
29-INTAKE
30-DISCHARGE
31-TURBO CIRCULATING PUMP
32-MOTOR-CENTRIFUGAL CONDENSATE PUMP
33-TURBO DRIVEN AIR PUMP
34-TRAP
35-SMOKE FLUE
36-LUBRICATOR
37-PUMP REGULATOR
38-TRAP
39-HOT WELL
40-HOUSE DUPLEX PUMP
41-GOVERNOR
42-TURBO-DRIVEN BOILER FEED PUMP
43-STORAGE TANK
44-FEED-WATER METER



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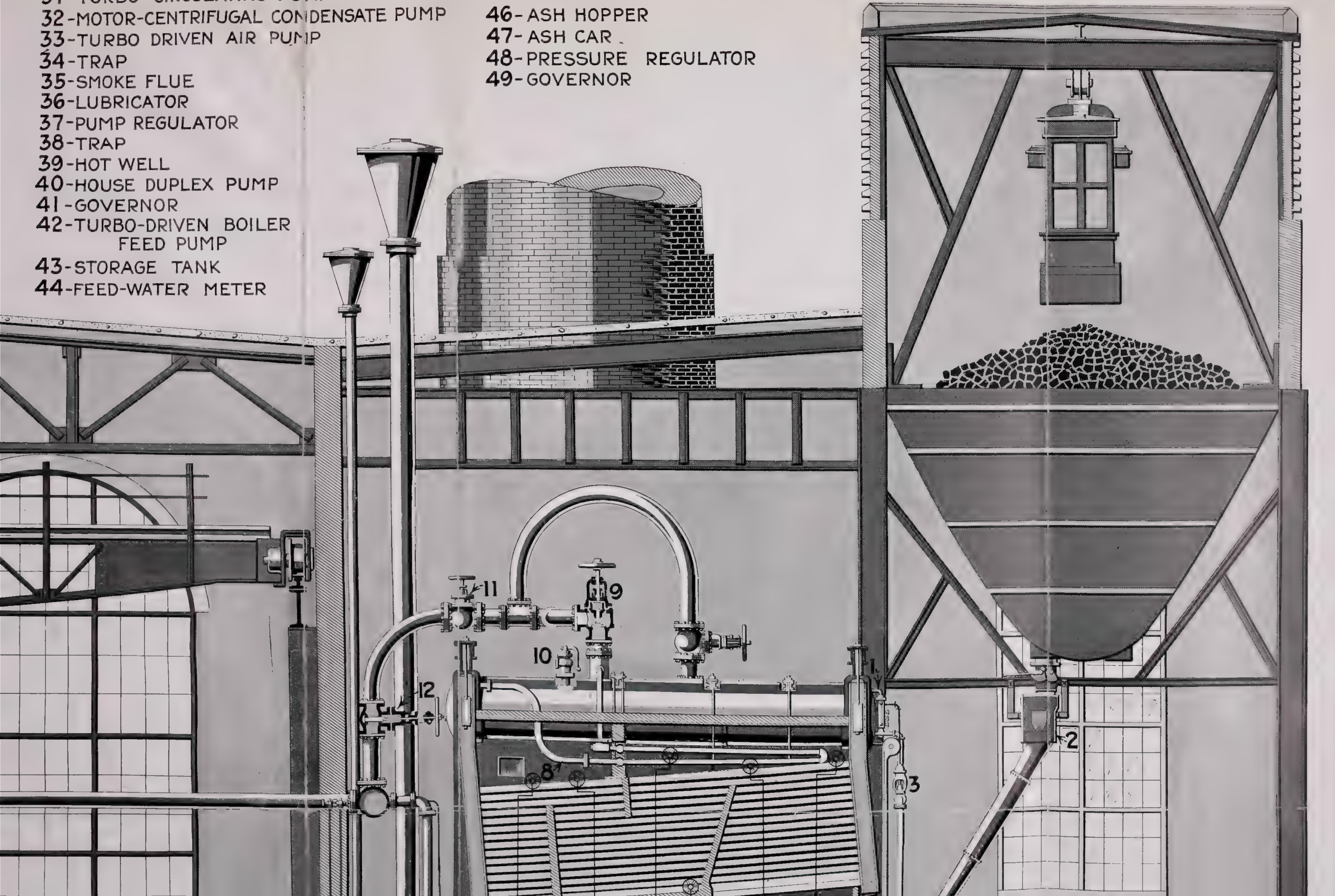
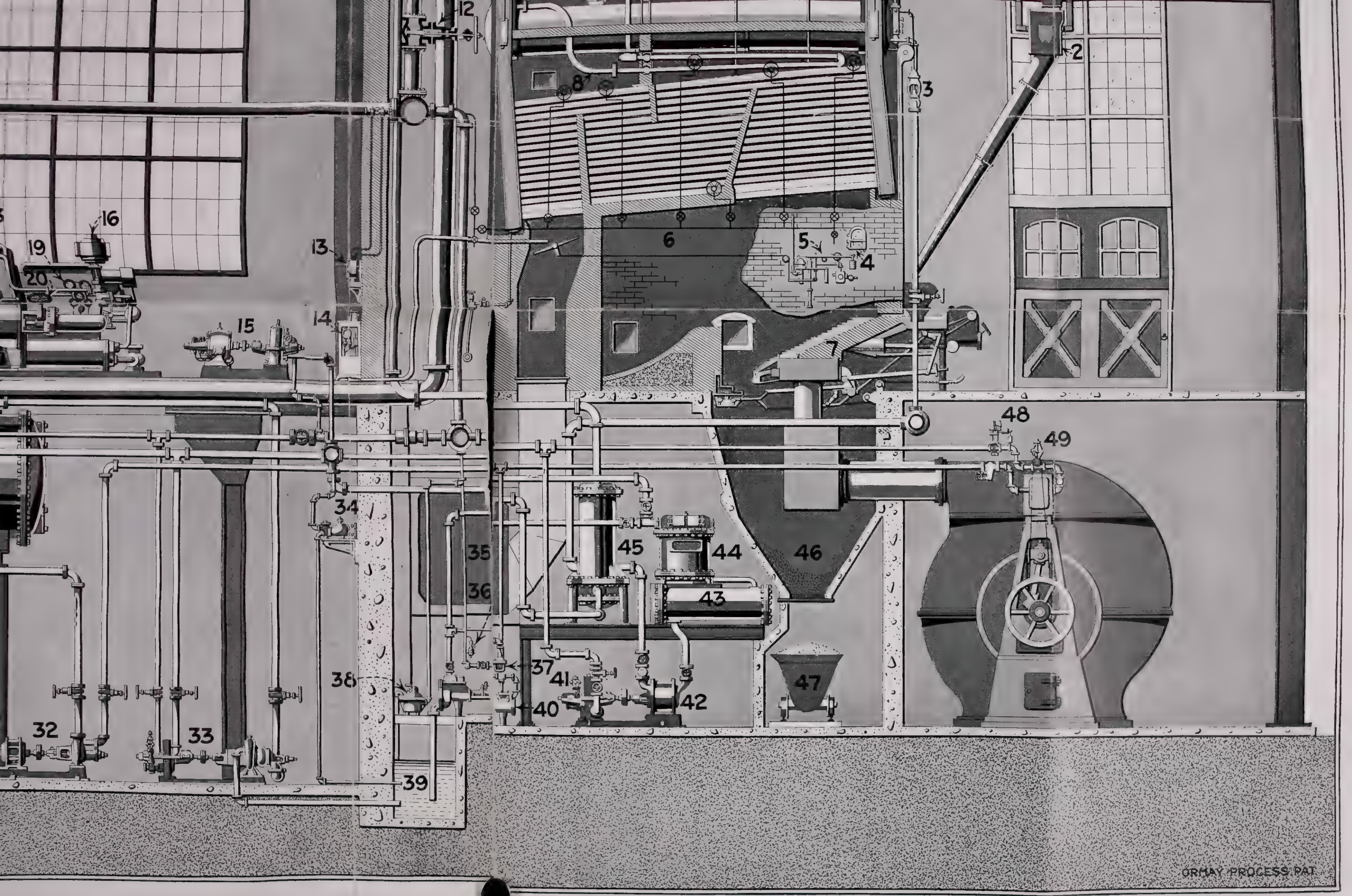
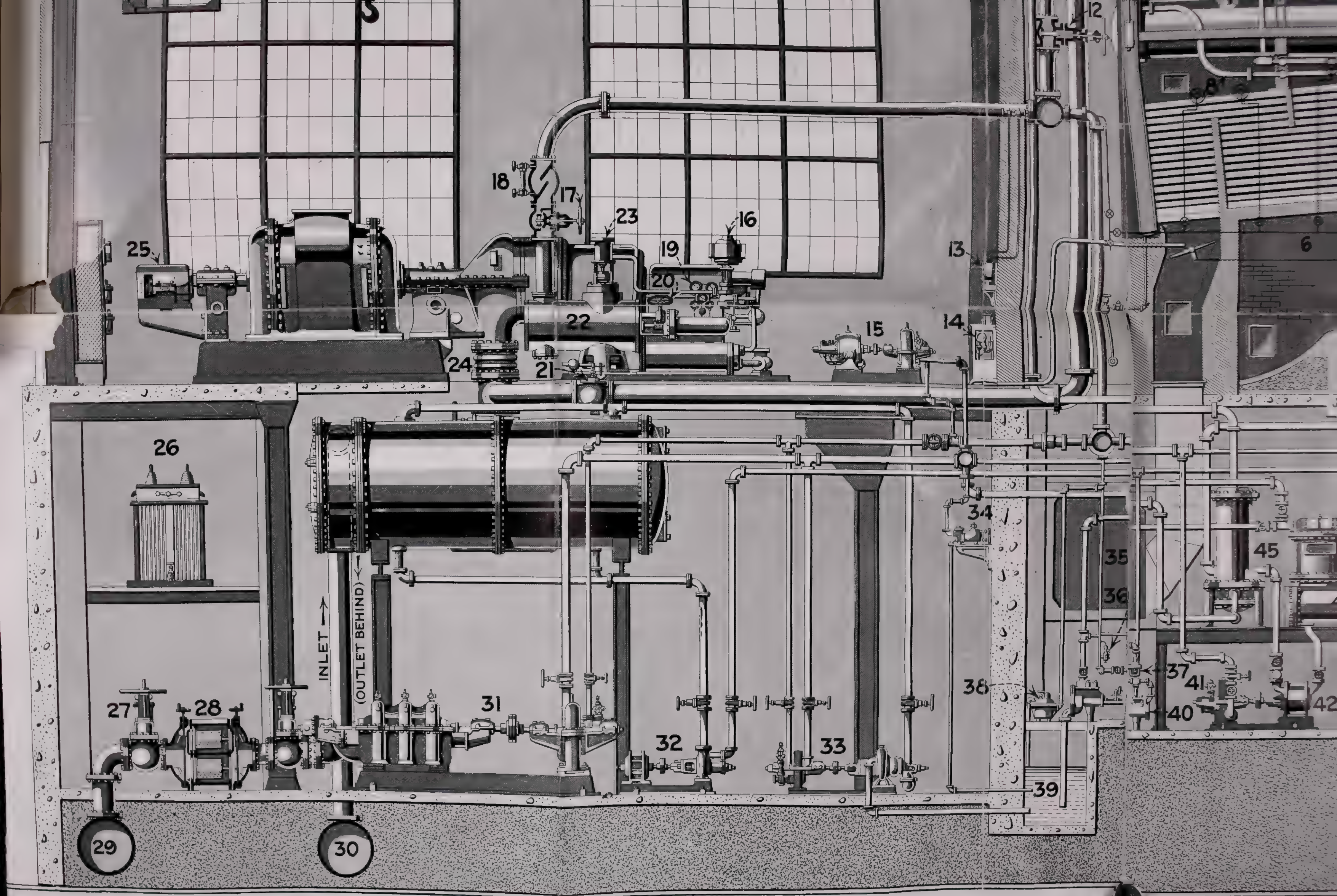
35-SMOKE FLUE
36-LUBRICATOR
37-PUMP REGULATOR
38-TRAP
39-HOT WELL
40-HOUSE DUPLEX PUMP
41-GOVERNOR
42-TURBO-DRIVEN BOILER FEED PUMP
43-STORAGE TANK
44-FEED-WATER METER
45-HEATER
46-ASH HOPPER
47-ASH CAR
48-PRESSURE REGULATOR
49-GOVERNOR





ncipal Equipment Found in Typical Steam Turbine Generating Station

Supplement to Power, March 25, 1919.



Principal Equipment Found in Typical Steam Turbine Generating Statio

POWER

Volume 49 New York, March 25, 1919 *Number* 12

Rubber Balloons and Reputations

By RUFUS T. STROHM

YOU'VE seen these toy balloons that hawkers sell to children at the County Fair and to grown-ups during Old Home Week. At first sight there's nothing to them. They look like a bunch of dejected frankfurters.

You take one of them and you begin to blow into it. First off, it straightens out like a sore finger. Then it begins to grow and before long it looks like a watermelon with the jaundice. You keep on blowing, watching it swell, till it gets so thin you can almost see through it.

At that stage you have a feeling that maybe you had better stop, but you overrule your timidity and decide to give it one more lungful. Then the blamed thing goes "plop!" leaving you with a hunk of rubber and a foolish expression.

The trouble is you've forgotten about the factor of safety.

That's what many a man does when he starts to advertise himself.

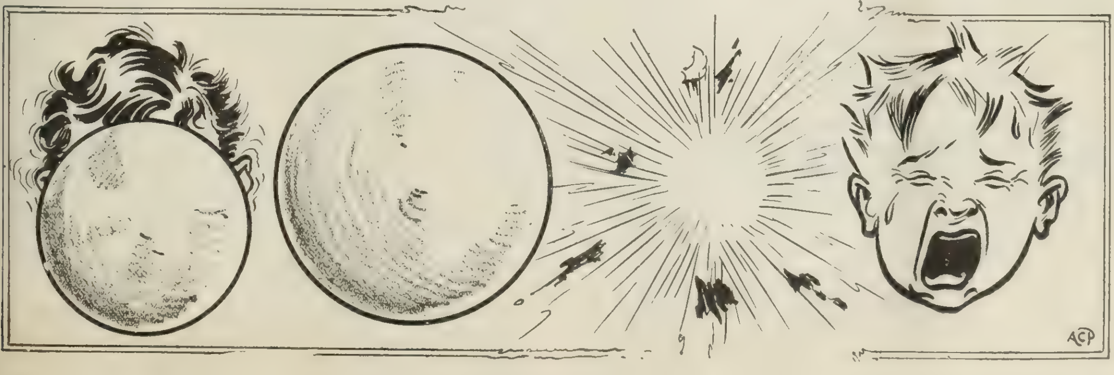
At first he's sort of fearful about it. He gives his reputation a gentle little puff and is tickled pink to see how it perks up. Instead of a limp and sickish-looking thing, it stands out so that folks take notice of it.

He draws a long breath, blows once more and notes greater rotundity and increased prominence. He blows again and again and marvels at the result. Apparently there is no limit to the expansion.

The thing grows till he loses all sense of its size. It is so close to him that it obscures his vision and he sees only its sweeping curves. But it seems to show no signs of strain, so he gives himself up to a riot of blowing.

Then, without warning, it goes "bang!" and he finds himself alone with a vain regret and the echo of unsympathetic laughter.

You can stretch almost any old reputation if you patch up the weak spots and vulcanize the seams. But you've got to use judgment as to when to stop.



United States Nitrate Plant, No.2

at Muscle Shoals, Ala.

THE BOILER ROOM

By Charles H. Bromley

The first of several articles describing fully the large steam-power station of United States Nitrate Plant No. 2, at Muscle Shoals, Ala., where great quantities of ammonium nitrate were to have been made by the cyanamid processes for the Ordnance Department of the Army. Data are given on the flow and available power of the Tennessee River at Muscle Shoals, Ala. The conditions upon which to base the design of this interesting war steam station of 90,000 kw. are the most ideal engineers have yet encountered. The combustion volume in the boiler furnaces is 11.6 cu.ft. per sq.ft. of active stoker-grate area; the settings are of the most modern type. A total steam temperature of 590 deg. F. will be used, though a somewhat higher temperature may be used later. The plant-load factor will be about 95 per cent., the load being chiefly electric furnaces. Accompanying the article is a table giving many important data covering the entire station, data which the designing, consulting and operating engineer would like to file. A plant thermal efficiency of 20 per cent. is expected.

LET us first get a perspective view of Muscle Shoals that we may the better assess what will follow.

The steam station is on the Tennessee River at Muscle Shoals, about three miles from Sheffield and about the same distance from Florence. As is well known, the Tennessee River is pregnant with great power possibilities, and cheap power, when coal, iron and many raw materials are near at hand, as they are in that part of the South, coupled with the fact that it is only about 300 miles to seaports on the Gulf of Mexico and a little more to others on the Atlantic Seaboard, will likely lead to the development of this section of the country.

Many power studies of the Tennessee River have been made, particularly during the last 32 years. The chart, Fig. 1, shows the energy available at Muscle Shoals; study of it is worth while; but only a few figures will be given here to acquaint the reader with the river. The maximum flow at Florence, Ala., was 499,000 c.f.s. for two hours on Mar. 19, 1897, gage height 32.5 ft. The minimum flow recorded at the same place was 7000 c.f.s., gage height —0.8 ft., October, 1872 and September, 1878. The flow has never been up to 240,000 c.f.s. from April to October, and 150,000 c.f.s. averages only once every two years. The average flows for a period of 32 years are given below.

AVERAGE FLOWS OF TENNESSEE RIVER AT FLORENCE FOR 32 YEARS

Number of Days per Year Flow Was Above Cubic-Foot-Seconds

50,000	100,000	150,000	200,000	250,000	300,000	400,000
Gage Height, Ft.						
5.2	9.7	13.4	16.6	19.6	22.4	27.6
122.9	47.9	23.4	11.8	5.6	2.4	0.35

The commercial power available from the river at Muscle Shoals, connected with other plants, is estimated by army engineers at 600,000 hp.

The total cost of the project now under way for water-power development at Muscle Shoals was estimated in October, 1917, to be $14,534,000, based upon then prevailing wages and prices of materials. On Feb. 23, 1918, because of the low price of cement for the Government, the estimate was reduced to $14,000,000. This estimate includes the dam locks and flowage rights and the power house with hydro-electric machinery capable of generating about 120,000 hp. The power-house substructure will be constructed so as to provide for placing additional units in the future if desired, in order to utilize the noncontinuous or secondary power in connection with steam-generating units already installed in Nitrate Plant No. 2. It is estimated that about three years will be required for the completion of the project. Of the power to be furnished by the project, it is estimated that approximately 72,000 hp. will be continuous throughout the year. In all but the dry-up year it is to be expected that approximately 100,000 hp. can be developed continuously. The figures in this paragraph are by Benedict Crowell, Assistant Secretary of War.

There have been many proposals for hydro-electric development at Muscle Shoals. One study proposes ten 18,000-hp. turbines for No. 3 dam and twelve 48,000-hp. units for No. 2 dam. The dam sites have been selected, but the plants have never been built. Transmission lines now connect the Muscle Shoals district with the Warrior River steam station 90 miles away on the Warrior River, and with "Lock No. 12," a hydro-electric station on the Coosa River 160 miles away; both are properties of the Alabama Power Co. Such, broadly, are the geographical and economic circumstances surrounding the large steam station of United States Nitrate Plant, No. 2, though the plant was built to furnish power only to the nitrates plant. The data on river flow are from Document 1262, Sixty-Fourth Congress, First Session, Committee on Rivers and Harbors.

As stated, the new steam plant at Muscle Shoals was built to furnish current for the manufacture of ammonium nitrate by the cyanamid processes for the Government, the Air Nitrates Corporation acting as agent for the Ordnance Department of the United States Army. The station was designed for 90,000 kw. in two main units, one 60,000 kw. normal rating, three-cylinder reaction turbine, and one 30,000-kw. tandem-compound double-flow reaction turbine. In the middle of February, 1918, the ground where the station now stands was a ravine, virtually a virgin forest. Steam has been on the plant four months, and the large main unit is about ready to run. Here, indeed, is an achievement in power-plant design, construction and installation, considering labor, traffic and other conditions. The 30,000-kw. unit will not be installed for the present.

The plant was designed to meet conditions which are by far the nearest approach to the ideal that engineers have ever encountered, so far as the writer and those consulted by him know. It is indeed important that the reader have in mind these conditions when reading the articles, for if he does not have them in mind, but has instead the usual conditions of load factor, etc., he may misjudge.

The station load factor will be 95 per cent. The load is chiefly electric furnaces, of which 12 are called for, 10 to operate continuously, 2 as spares. There are many load curves of these furnaces, and each takes 6000 kw., the plotted line on the recording meter being as uniform as one could carefully draw the line free-hand. The power factor of the furnaces is 86 per cent. at 160-volt operation. The 60,000-kw. three-cylinder main turbine is designed for 85 per cent. power factor; but with the machine up to 90 per cent. power factor a

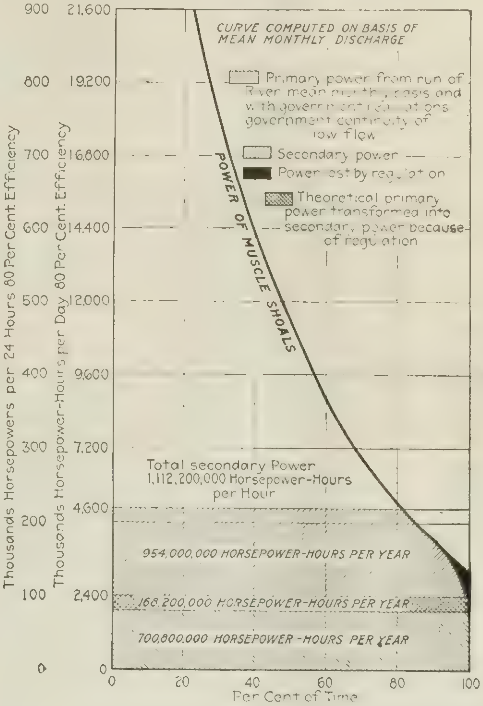


FIG. 1. CHART SHOWING WATER POWER AVAILABLE FROM THE TENNESSEE RIVER AT MUSCLE SHOALS

FIG. 2. THE TENNESSEE RIVER AT MUSCLE SHOALS

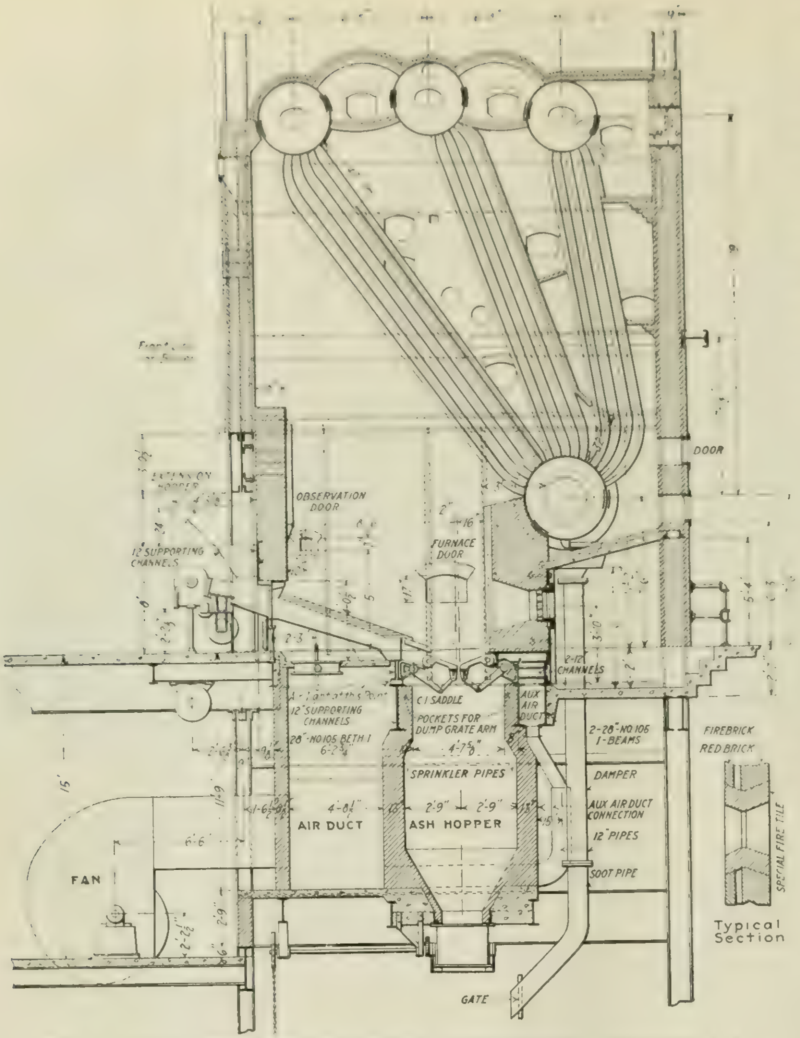


FIG. 3. BOILER, FURNACE AND STOKER CROSS-SECTION, CARRYING ALL IMPORTANT DIMENSIONS

load of 70,000 kw. can be carried without trouble. The water-rate guarantees on the turbine are very low. These, with all other important data, capacities, ratios, etc., the writer has prepared in tabular form convenient for the engineers' notebook, and appear in this article.

An unusually low unit coal consumption is expected; some of those directly interested expect it to be near 1 lb. per kilowatt-hour.

Coal of remarkable composition is available, the analysis being as follows: Fixed carbon, 59 to 60 per cent.; volatile, 35.7 per cent.; sulphur, 0.8 per cent.; moisture, 1.5 per cent.; ash, 4 per cent. The boiler radiation will likely be down to 2½ per cent. because of the use of heat-insulating brick, and the stokers and volume of furnace are such that a boiler efficiency of 76 to 78 per cent. may confidently be expected. The feed water will be kept at 220 deg. F. constantly. All drives throughout the station, except feed pumps and two spare steam-driven exciters, are motor-driven. A large pumping plant for service process water is located in the power plant instead of in a separate station, and these pumps are each driven by a 700-hp. induction motor from current generated by two house turbines each of 2000 kw. capacity, noncondensing, which also supply current for all auxiliaries.

A plant thermal efficiency of at least 20 per cent. is expected, and there are many reasons to believe it will be above this figure. A kilowatt will be put on the board for between 17,000 and 18,000 B.t.u. or better. If one has in mind the unusually favorable conditions for which the plant was designed, one will agree that the performances expected are certain of realization, and that the designing engineers are not overoptimistic.

THE BOILER ROOM

The boiler room and its equipment are admirable in design, arrangement and operation. There are 12 type M-55 Stirling boilers each having 15,070 sq.ft. of heating surface with 15-retort Westinghouse underfeed stokers set as shown in sectional side elevation, Fig. 3. The lower drum is set 7 ft. 6 in. from the normal boiler-room floor, giving a furnace volume of 11.6 cu.ft. per sq.ft. of active grate area, adequate to permit of unusually thorough mixture of air and gases at ratings up to 300 per cent., which is far above the 150 per cent. rating normally required. This is particularly true for the excellent coal with which the plant will be supplied. A view of the boiler furnaces during construction is

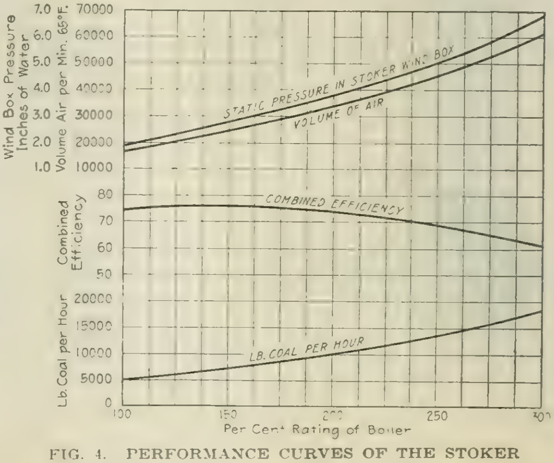


FIG. 4. PERFORMANCE CURVES OF THE STOKER

shown in Fig. 6. The ash hoppers under the furnaces are unusually large, having capacity of 225 cu.ft. each. Each of the ash cars used for hauling ashes away from the boiler room has a capacity of 1½ cu.yd. The front boiler wall is supported independently of the stoker, and the front furnace wall is so arranged that it is independent of the front boiler wall (see Fig. 3). Four fire-doors are placed in the bridge-wall, the distance center to center of doors being 8 ft.; a section of one of these doorways is shown in Fig. 3. The bridge-wall is 3 ft. thick, but its front is concaved 4½ in. at the center. It extends into the side-walls 3½ in. with 1 in. clearance for expansion. Special fire tile is used around each fire-door. All firebrick lining 9 in. and over is laid with four header courses to the fire, between single stretcher courses. Red brick only is used in the front and side walls below the stokers. The top joint between the top of the furnace-front wall and the front boiler wall is filled with asbestos; both these walls are 18 in. thick including the Silocel brick. The side walls are 2 ft. 3⅜ in. thick at the bottom, with 17½-in. firebrick lining, in four courses of 4½-in. brick around the dump plate; 13½-in. firebrick lining of three courses of 4½-in. brick from here up to within a couple of feet of the gas opening in the first pass; from this point to the top, in the first and second passes, 9-in. firebrick lining in two courses of 4½-in. brick, is used, while for the last pass the firebrick lining is but 4½ in. thick. The rear wall is 18 in. thick, of red brick and Silocel only.

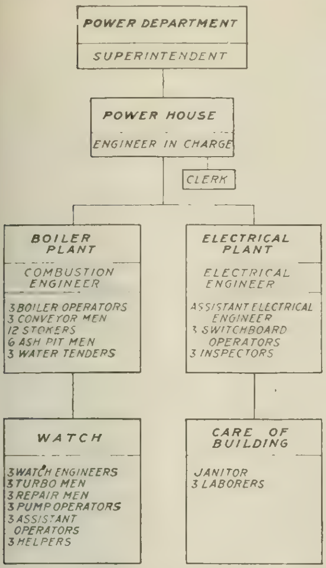


FIG. 5. ORGANIZATION OF PERSONNEL OF MUSCLE SHOALS POWER PLANT

The gas opening in the first pass is 42 in. wide, in the second pass 32 in. wide and in the last pass 17 in. wide. The free area for the passage of gases is: First pass, 40 sq.ft.; second pass, 30.6 sq.ft.; third pass, 16.3 sq.ft. The damper opening is 22 in. wide. All joints in the tile baffles are made on the tubes, the tile being broken where necessary in order to bring the joint on the tube.

The stoker width is 26 ft. 5¼ in. The lineshafting is supported from the stoker ram boxes, and each stoker is operated by an independent adjustable-speed motor, 230-volt direct-current field control, 8 hp. at 200 r.p.m. and 13.5 hp. at 1500 r.p.m. Clutches are provided so that any of five groups of three rams each may be stopped temporarily to adjust the fuel bed.

Clinker grinders—that is, rotary ash-discharge apparatus—have not been installed, as the coal eventually to be used has less than 5 per cent. ash of an unusually high fusion temperature.

The curve, Fig. 4, gives the stoker performance based on coal of fixed carbon 56.74 per cent., volatile 29 per cent., moisture 4.23, ash 11.13 per cent., sulphur 2.58 per cent., B.t.u. per lb. 13,000—a very poor coal compared with that with which the plant normally will be supplied. At 150 per cent. rating the guaranteed combined efficiency is 76 per cent., at 175 per cent. rating, 75 per cent. The continuous capacity is 235 per cent.; 275 per cent. for 4 hours. There are three radial-brick chimneys, each 275 ft. high above the boiler-room floor. The internal diameter of the middle chimney is 18 ft.; that of the other two, 14 feet.

The railroad runs to the plant and above the four coal crushers of 100 tons capacity per hour, the coal being dumped directly into the crushers from the cars which in turn bring it from the mine. From the crushers it is conveyed to four 24-in. belt conveyors, each of 100 tons per hour capacity, driven by 15-hp. motors which deliver it to the bunkers. The latter are of steel-frame concrete-lined construction with capacity for 4½ days' normal operation. The yard-storage capacity is 25,000 tons. There are four one-ton larries to each firing aisle which, by the way, is 25 ft. wide.

Each boiler has its individual forced-draft radial-flow double-inlet fan. Each fan has two 60-cycle three-phase squirrel-cage induction motors, one 40 hp. for a speed of 875 r.p.m., and one 75 hp. for 1170 r.p.m. Against 3-in. static pressure these fans will deliver 25,500 cu.ft. per min. (745 r.p.m.); against 5.1 in. pressure, 40,500 cu.ft. per min. (895 r.p.m.); against 6 in., 48,000 cu.ft. per min. (1200 r.p.m.).

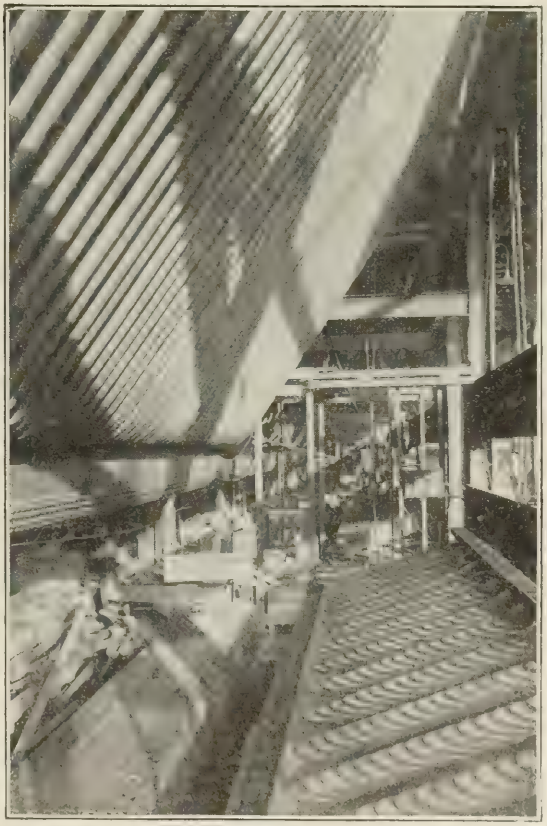


FIG. 6. VIEW OF BOILER FURNACE, INTERIOR, DURING CONSTRUCTION; NOTE LARGE COMBUSTION VOLUME

This arrangement of fans, it is realized, is rather unusual, not so much because one fan is furnished each boiler, but because each fan has two motors to drive it. The control of the draft is as automatic as reliable apparatus can make it consistent with efficient operation, and these fans will cut in and out automatically. The intakes to them are short and the air will be quite clean despite the lime and carbide dust from the cyanamid plant.

The treatment is as follows: Pounds of soda per 1000 gal., 0.27; pounds of lime (50 per cent.) per 1000 gal., 0.55. Two 15,000-hp. feed-water heaters are used, each with water capacity of 481 cu.ft., weighing when full of water, 66,337 lb.; empty, each weighs 30,000 lb. The boiler-feed pumps are all centrifugal, 5-in. four-stage, 750 gal. per min., each driven by a three-stage 2650-r.p.m. steam turbine.

Consideration was given economizers, but they were not installed as they did not show a commercial economy with coal of the price and quality it is possible to obtain. Provision is made for their installation should conditions change and their use be warranted after the plant has been operated for some time.

The boilers are built for 300 lb. pressure and hy-

Important Data on Power Plant of United States Nitrate Plant No. 2 Muscle Shoals, Alabama

GENERAL

Location, Muscle Shoals, Ala., on the Tennessee River near Sheffield and Florence
Main gen rating capacity, kw (in one unit) 60,000
Service generating capacity, kw. (non-condensing) 4,000
Auxiliary and other drives ..... Practically all motor
Station load factor, per cent ..... 90 to 95
Nature of load ..... Chiefly electric furnaces
Ammonium nitrate manufactured by the cyanamid processes

BOILER ROOM

Dimension, boiler house ..... overall, length 280 ft., 9 in.; width 158 ft. 9 in.
Width firing aisle, ft 25
Type of boilers ..... Stirling M-55
Number of boilers 12
Steam drums, three ..... 42 in. x 31 ft.; plate, 1 9/32 in.
Mud drum ..... 42 in. x 28 ft. 6 in.; plate, 1 15/32 in.
Tubes: Number of, 1156; dia. 3¼ in. hot rolled seamless; No. 8 gage, 300 lb.
Heating surface, sq ft 15,070
Superheater surface, each boiler, sq.ft 1,950

Superheater performance:

Rating of Boiler, Per Cent.	Superheat, Deg. F.
100	155
150	175
200	193
250	207
300	215

Grate surface (active), sq ft 284
Heating surface per sq.ft. active grate area, sq.ft 53
Heating surface per sq.ft. superheater surface, sq.ft 7.7
Superheater surface per sq.ft. grate surface, sq.ft 6.86
Heating surface per installed kilowatt normal capacity of generators 2.94
Pressure, lb per sq. in. 275
Superheat, deg. F 175
Total steam temperature, deg. F 589.4

Coal analysis, temporary supply and upon which stoker performance is based:

Fixed Carbon	Volatile, Per Cent.	Moisture	Ash	Sulphur	B.t.u. per Lb.
56.74	29.00	4.23	11.13	2.58	13,500.

Coal analysis, permanent supply:

Fixed Carbon	Volatile, Per Cent.	Moisture	Ash	Sulphur	B.t.u. per Lb
	35.7	1.5	3 to 5	0.8	15,000

Boiler settings (no arches) ..... Width, ft., 31, depth, ft., 21
Height, center of lower or mud drum to floor line ..... 7 ft. 9 in.
Insulating brick "Silocel," thickness, in 4.5
Firebrick, ... "Empire" (Missouri clay)
(Adamant cement used in boiler settings)
Estimated radiation loss, per cent 2.5
Combustion (furnace) volume per sq.ft. active grate area, cu.ft 11.6
Combustion volume per stoker retort, cu.ft 220
Combustion volume:

Boiler Rating Per Cent.	Pounds of Coal Fired per Hr. per Cu.Ft. Combustion Volume
100	1.53
150	2.23
175	2.64
200	3.06
250	4.15
300	5.56

Free area of opening in first pass, sq ft 40
Free area of opening in second pass, sq.ft 30.6
Free area of opening in third pass, sq.ft 16.3
Free opening in first pass per sq.ft. active grate area, sq.ft 0.1409
Free opening in second pass per sq.ft. active grate area, sq.ft 0.108
Free opening in third pass per sq.ft. active grate area, sq.ft 0.0585
Stokers, type, Westinghouse underfeed, 15 retorts per boiler
Stoker drive, Morse type chain, motors, 13.5 hp. each, adjustable speed; 8 hp. at 200 r.p.m.; 13.5 hp. at 1500 r.p.m
Active grate area, sq ft 284
Stoker performance (based on coal, 13,500 B.t.u. per lb., ash, per cent, 11.13):

Boiler Rating, Per Cent.	Combined Boiler and Furnace Efficiency, Per Cent.	Pounds of Coal per Retort per Hr. as Fired	Pounds Coal per Sq.Ft. Active Grate Surface	Volume of Air per Min. at 65 Deg. F. Cu.Ft.
100	74	336	17.75	16,500
150	76	491	25.90	24,500
175	75	580	30.60	29,000
200	74	674	35.50	33,500
250	68	914	48.10	45,000
300	61	1220	64.50	61,000

Continuous capacity of 235 per cent. boiler rating
Four hours continuous at 275 per cent. boiler rating.

Coal Handling: Railway cars dump into crushers above coal bunkers
Crushers, two, Webster type, double-roll, capacity each, tons 100
Bunkers ..... Steel frame, concrete
Installed kilowatts per ton of bunker capacity, kw 14.7
No. of days storage at normal operation (4200 tons) 4.5
Bunker capacity per stoker retort, tons 23.3
Yard storage, tons, minimum capacity 25,000
Larries, four for each firing aisle, capacity each, tons 1
Larry capacity per stoker retort, tons 0.034
Conveyors, belt, four 24-in., capacity each, tons 100
Conveyor (belt) hourly capacity per stoker retort, lb. 4460 tons 2.23
Ratio conveyor hourly capacity to hourly capacity per stoker retort at 250 per cent rating 4.45:1
Capacity furnace ash hoppers, each, cu.ft. 850.5; cu.yd 38.8
Capacity ash cars, each, cu.yd 1.5
Soot blowers, Diamond type ..... 7 units on each boiler
Main steam valves ..... Jenkins type
Automatic stop valves ..... Edwards type
Blow-off valves ..... Gato type
Feedwater heaters, two, Cochran type, horizontal, capacity each, boiler hp 15,000
Water capacity, each heater, cu.ft 481
Heater capacity per rated horsepower capacity of boilers installed, boiler hp 1.67
Heater capacity per sq.ft. boiler heating surface, boiler hp 0.166
Feed Pumps ..... Worthington
Type, centrifugal, 5-in., four-stage, 750-gal. per min., 2650 r.p.m. driven by 250-hp. steam turbine

Feed Water Analysis:

	Grains per Gal.
Calcium carbonate	3.44
Magnesium	0.35
Magnesium sulphate	0.23
Magnesium chloride	0.23
Silica	1.11
Iron oxide and aluminum	0.41
Sodium and potassium chloride	0.82
Volatile and organic	1.29
	7.88
Suspended matter	1.92

Feed Water Treatment
Pounds of soda per 1000 gal 0.27
Pounds of lime (50 per cent.) per 1000 gal 0.55
Water softener, American, steel tank, tipper type, capacity, gal per hr 8,000
One cypress tank, dimensions, ft 16x18
Chimneys: Kellogg radial brick:
Two, 275 ft. x 14 ft., base diameter, 23 ft. 3 in.
One, 300 ft. x 18 ft., base diameter, 26 ft.
Coal burned per sq.ft., minimum cross-sectional area at 250 per cent. boiler rating (based on six 1500-hp. boilers to one 275 ft. x 14-ft. chimney), lb per hr 534
Forced-draft fans: Green type No. 5 radial flow, double inlet, full housing, one for each boiler
Two motors to each fan, each 60 cycle, three-phase, 2200 volt, squirrel-cage induction type, one 40 hp., 875 r.p.m.; one 75 hp., 1170 r.p.m.
Performance:

Cu.Ft. per Min.	Static Pressure, In. Water	Horsepower	R.P.M.
25,500	3	17	720
40,500	5	49	1030
48,000	6	72.5	1170

Capacity per sq.ft. active grate, cu.ft. per min., minimum 95, maximum 176
Capacity per cu.ft. furnace volume, cu.ft. per min., minimum 8.2, maximum 15
Instruments for the boiler room
Recording steam meters, Bailey type, maximum flow at 300 lb., 175 deg. F. superheat, lb. per hr 56,200
12 type D-26, class 5 recording steam-flow, air flow and flue-gas temperature
12 type D-26, class 9 recording steam-flow, air-flow and speed of stokers
12 "Precision" three-in-one gages for air pressure in ashpit and last pass in boilers
12 electric indicating tachometers for stokers
2 standard-weight venturi meter tubes with type M register-indicator-recorder
2 double-extra-heavy venturi meter tubes with type M register-indicator recorder

TURBINES

Main turbine, Westinghouse
Type: cross-compound triple cylinder unit, pure reaction, parallel flow
Capacity: 60,000 kw. at 85 per cent. power factor, 60 cycle, three-phase, 12,200 volt
Peak load for short period, kw 70,000
Dimensions: Length 53 ft. 8 in., width 56 ft. 2 in. height 19 ft. 3 in.
Weight, total shipping, lb 2,600,000
Heaviest piece for crane, lb 142,000
Capacity per sq.ft. floor space covered by turbine, kw. (rated capacity) 20

Weight of turbine per rated kilowatt, lb.	43.34
Speed, high-pressure element, r.p.m. 1800, low-pressure elements, r.p.m.	1,200
Blading material: High-pressure element, phosphor bronze; low-pressure elements, phosphor bronze, except last three rows, which are elec. M. steel	
Peripheral speed last row blading on low-pressure elements, ft. per sec. Tip speed, 608; Mean speed, 514	
Main steam inlet 26 in. dia., supplied from two 18-in. headers	
Total exhaust area, sq.ft.	452
Clearance, axial: High-pressure, in., ½ in. min.; low-pressure elements, in., 5/16 min.	
Clearance, tip: High-pressure, in 0.045 to 0.055, low-pressure elements, in. 0.05 to 0.08	
Bearing speed, ft. per sec., high pressure, 78.6; low-pressure	73.4
Unit load on main bearings, lb. per sq.in., high-pressure, 80; low pressure	124
Thrust bearing	Kingsbury segmental
Normal oil circulation through main-bearings, gal. per min., each high-pressure, 10; low-pressure each	12.5
Normal oil circulation on each, thrust bearing, gal. per min.	20
Oil-cooler surface, total for both coolers, sq.ft	1,200
Oil-cooler surface per kw. turbine capacity, rated, sq.ft.	0.02

Performance: Operating conditions, 290 lb. abs., 175 deg. F. superheat, when operating as complete expansion unit:

	Vacuum	
	29 In.	28.5 In
Load	Pounds of Steam per Kw.-hr	
30,000	11.05	11.55
40,000	10.75	11.15
50,000	10.55	10.90
60,000	10.75	11.10

When operating one high- and one low-pressure element

	Vacuum	
Load	29 In.	28.5 In
	Pounds of Steam per Kw.-hr.	
30,000	12.1	12.45

When operating one low-pressure element alone on high-pressure steam

	Vacuum	
Load	29 In	28.5 In
	Pounds of Steam per Kw.-hr	
20,000	14.0	14.45

Excitation: High-pressure generator, 90 kw., 240 volts; low-pressure generators, each, 115 kw., 240 volts	
Main-unit capacity per kw. capacity excitation, kw	187.5
Ventilation: Two air washers, capacity each, cu.ft. per min.	115,000
Three 60-cycle, three-phase, 2200-volt motor-driven fans, capacity each, cu.ft. per min	75,000
Two 24-hp. motor-driven pumps, capacity each, gal. per min.	640

CONDENSERS

Type	Westinghouse
No. of, four, condensing surface, each, sq.ft.	25,000
Tubes: Muntz metal; No. of, 5,285; diameter, in., 1; active length, 18 ft. 3¾ in.	
Weight of condenser with tubes, empty, lb	220,000
Weight of condenser with tubes, full of water, lb.	405,000
Length of connection between turbine exhaust and condenser, ft.	30.5
Condenser support; hung from four keys fitting into exhaust connection and turbine steel foundation just under expansion joint at turbine exhaust	
Lifting effect of vacuum at each exhaust opening, lb.	223,000
Tube surface per kw. of turbine served, sq.ft.	1.67
Circulating pumps, centrifugal	Westinghouse type
Number of, 4; capacity each, gal. per min	44,000
Drive, induction motor, 550 hp	500 r.p.m.
Total pumping head, exclusive of head through condenser, ft.	9.0
Level of intake water below discharge water, ft.	3.5
Level of cold well below center line of pump, ft	15
Circulating-pumping capacity per kilowatt, gal. per min. max., 2.94; normal	2.2
Circulating-pumping capacity per sq.ft. condenser tube surface, gal. per min., max., 1.76, normal	1.32
Circulating-pumping capacity per lb. steam condensed at consumption of 10.75 lb. per kw.-hr . 60 deg. F. water, lb	136.5

NOTE: Circulating pumping capacity based upon four pumps of 44,000 gal. per min. each.

Condenser performance:

Lb. of Steam Condensed per Hr.	Circulating Water, Deg. F.	Vacuum, In. of Mercury
400,000	80	28.45
	60	29.15
	40	29.30
500,000	80	28.30
	60	29.05
	40	29.25
600,000	80	28.15
	60	29.00
	40	29.20

Intake: Open forebay with stop logs deflecting debris downstream	
Discharge tunnel, concrete, square section	
Intake screens: six Link Belt type, 78 in. wide, traveling	
Each screen 6 ft. 4½ in. wide between centers of chains, 45 ft. long, speed, ft. per min.	[illegible]
Screen trays use No. 10. U. S. S. gage galvanized-steel wire cloth	
Total screen capacity (water) at 12 ft. level, cu.ft. per sec.	51[illegible]
Drive, two 10-hp. motors	865 r.p.m
Total weight of screens, lb.	131,000
Condensate pumps, capacity 400,000 lb. per hr. each, head, ft.	96
Submergence head, ft.	3.5
Drive, induction motor, 75 hp	1750 r.p.m
Air pumps: Le Blanc type, water requirements, gal. per min.	2,000
Suction lift, including friction, ft.	10
Discharge lift, including friction, ft.	4
Drive, induction motor, 100 hp.	700 r.p.m
House turbines	Westinghouse type

Two, 2000 kw. (2500 kv.-a.) 80 per cent. power factor, 60 cycle, three-phase, 2300-volt, 3600 r.p.m.

Pressure 275 lb., 175 deg. F. superheat, exhausting against back pressure of 5-lb gage

Dimensions: Length, 24 ft. 5 in.; width, 9 ft. 10 in.; height, 6 ft. 10 in

Weight: Total shipping, 81,000 lb.; heaviest piece for crane, lb., 9,000

Air washers: One of 8,000 cu.ft. per min., 60 gal. per min. pump, for each turbine

Performance:

Kilowatts	Power Factor, Per Cent.	Pounds Steam per Kw.-hr.
1700	80	28.1
1600	80	25.5
2000	80	26.6

Exciters (all exciters in the station)

One turbine-driven 300 kw., 250 volt d.c., 6000 r.p.m

Performance of turbine:

Kilowatts	Pounds Steam per Kw.-hr.	
150	39.1	First nozzle
225	34.8	
300	34.3	Both nozzles
375	31.7	

One turbine driven, 50 kw., 125 volt, d.c.

Performance of turbine:

Kilowatts	Pounds Steam per Kw.-hr.	
25	48.8	First nozzle
37.5	40.2	
50	39.6	Both nozzles
62.5	36.0	

Two 300-kw., 250-volt d.c., 900-r.p.m. generators; 450-hp. synchronous motor

Two 50-kw., 125-volt d.c., 1175-r.p.m. generators; 75-hp. induction motor

Oil filtering system	Richardson-Phenix Co
One No. 438 Peterson type C filter, capacity, gal. per hr	1,800
One No. 6 triplex oil pump, 3-hp. motor-driven, capacity, gal. per min.	30
One No. 12 type B filter, capacity, gal. per hr	90
One No. 2 triplex pump, capacity, gal. per hr	6
Pumps	
Process pumps, for nitrate plant supply	Allis-Chalmers type
No. of, 4, single-stage centrifugal, capacity, gal. per min. each at 200 ft. head	9,730
Drive, 700-hp. induction motor; efficiency, per cent	78
Domestic-supply pumps	
Two 4-in. three-stage centrifugal; capacity, gal. per min. at 200 ft. head	350
Drive, 40-hp. induction motor, 1760 r.p.m.; efficiency, per cent	55
Fire pump, Allis-Chalmers Underwriters type; capacity gal. per min.	750
Two-stage, 4 in., 1750 r.p.m.; efficiency, per cent	64
Sump pump, 4 in. Worthington type, vertical submerged, Class C volute, bronze impeller	
Drive, 15-hp. induction motor, 1200 r.p.m.; capacity gal. per min. at 50 ft. dynamic head	500

Bus tunnel connecting power house with switch house, length 4000 ft ; tile brick and concrete

Buses carry power at 12,000 volts from generators to switch house for distribution

(Open transmission lines would be too seriously affected by carbide dust from electric furnaces)

Rotating field synchronous condenser	Westinghouse type
Continuous rating at 0 per cent., leading power factor: kv.-a. input. 7500, volts	12,000
Ampere per terminal, 361; phase, 3; cycles, 60; poles, 12; r.p.m	60
Safe operating temperature for embedded insulation, deg. C.	150
Exciter, kw. at 125 volts	60
Losses, including exciter losses, kw	230

Disconnector switches; all are mechanically operated

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drostatically tested to 450 lb. per sq.in.; the operating pressure will be 275 lb., and the superheat will be 175 deg. F. at 150 per cent. boiler rating. Francis E. Bradford, power engineer for the Air Nitrates Corporation, intends to gradually work up to a higher total steam temperature if experience shows this can be successfully maintained. The superheaters have 1950 sq.ft. of heating surface each, and the performance to be expected is given by the following figures:

Boiler Rating, Per Cent.	Superheat, Deg. F.
100	155
150	175
200	193
250	207
300	215

Of course the superheat will be affected by the operating conditions; that is, by secondary combustion in the superheater chamber, should it occur. If the excess air were reduced to a minimum, the superheat would be slightly lessened below that given when greater quantities of excess air were used.

The piping in the boiler room is well designed and put up. All piping is beneath the boiler-room floor, and the steam leads from the boilers drop down through the floor to the ring headers. It is always quite impossible to give figures on the steam velocities allowed for in steam piping without at length qualifying one's figures because the lines must be of sufficient area to pass very much more steam in emergencies than they normally pass when all mains are in service. The normal velocity will be about 9000 ft. per minute.

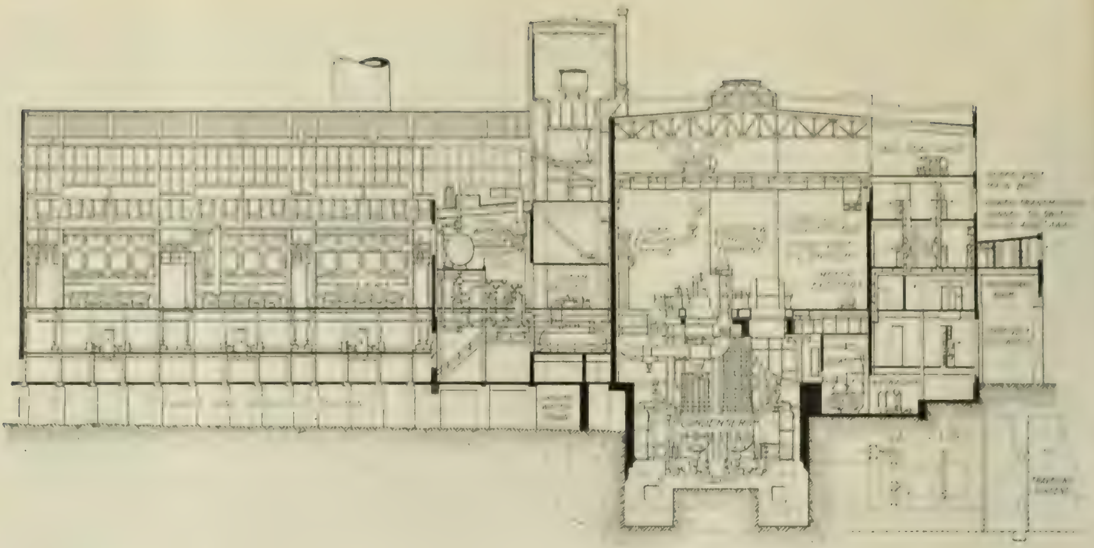


FIG. 7. CROSS-SECTIONAL VIEW OF THE POWER PLANT, LOOKING WEST

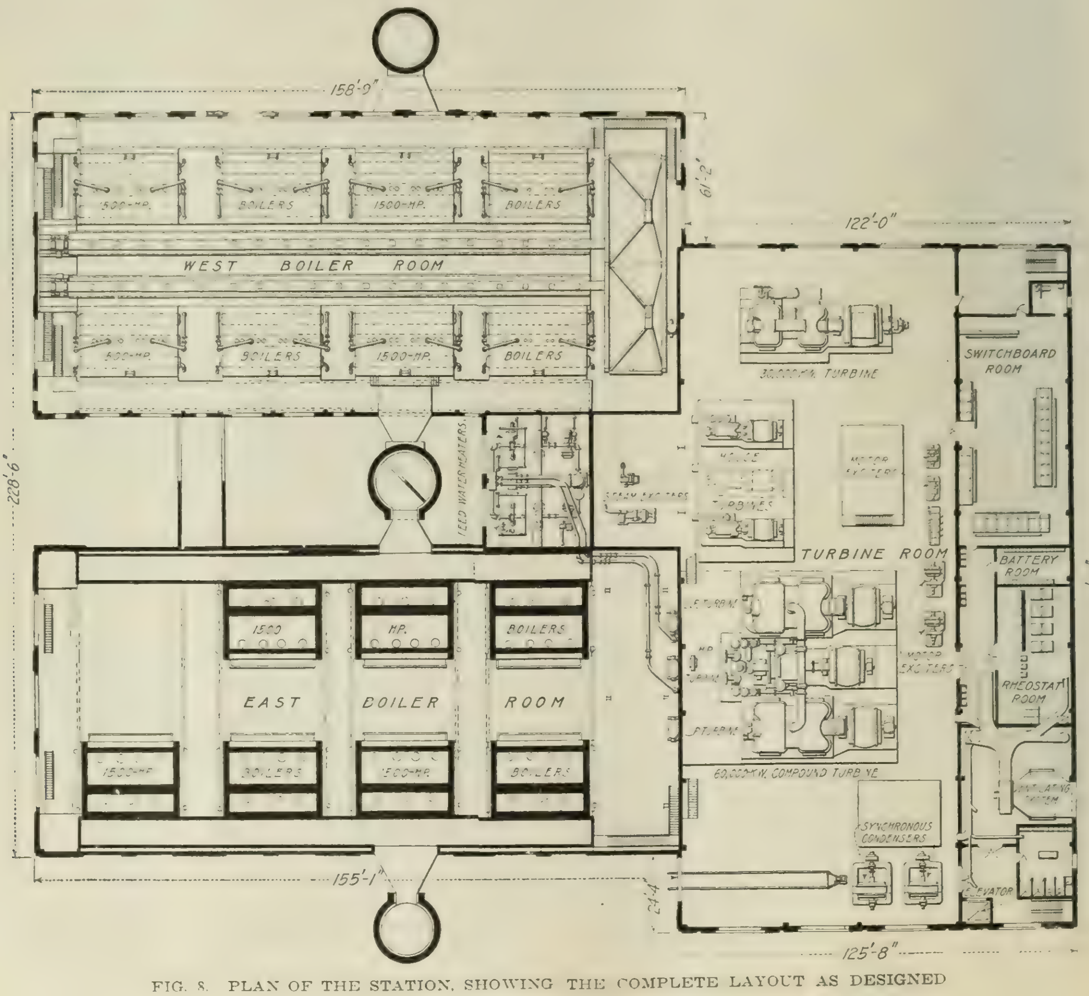


FIG. 8. PLAN OF THE STATION, SHOWING THE COMPLETE LAYOUT AS DESIGNED

Operation of the boiler room will be under the direction of a combustion engineer. All controls of stokers, draft fans, back dampers, and all indicating and recording instruments and gages are mounted on a board at the end of the boiler firing aisle. The chief engineer's office is situated so that one window bay fronts the main firing aisle and another looks out into the turbine room (see Fig. 7). A recording-gage board is installed in this office.

The J. G. White Engineering Corporation, New York, as subcontractors, designed and built the station under the immediate direction of F. E. Bradford, power engineer for the Air Nitrates Corporation; the architectural features were gone over by Ewing & Allen, architects, New York, and the Independence Bureau of Philadelphia made recommendations covering safety during construction and operation.

Other articles to follow relative to this plant are: The Main and House Turbines; The Condensing Equipment; Heat Balance Studies.

Green Cast-Iron Storage Hopper

To meet the varied objections to the use of wood, steel or reinforced concrete in storage hoppers, the Green Engineering Co., of East Chicago, Ind., has placed on the market a series of standard cast-iron hoppers to be used for the transfer of materials or for storage. Unit capacities range from 10 to 45 tons, and manifold hoppers composed of units can be furnished for any desired capacity.

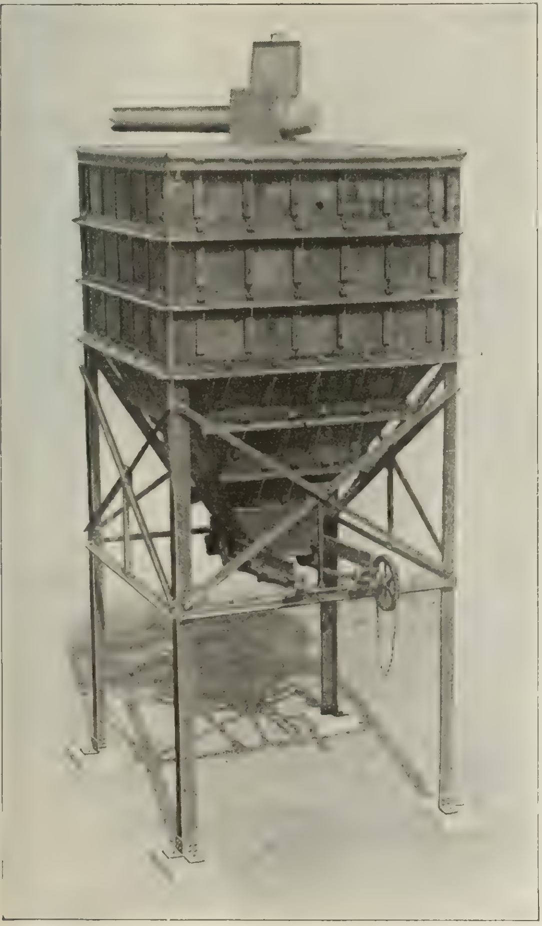


FIG. 1. CAST-IRON HOPPER USED AS ASH-STORAGE TANK

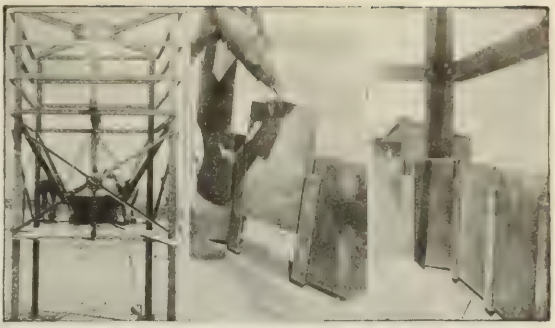


FIG. 2. ANGLE-IRON SUPPORTING STRUCTURE. FIG. 3. PUTTING CAST-IRON SIDE PLATES IN POSITION. FIG. 4. VIEW SHOWING CORNER CONSTRUCTION

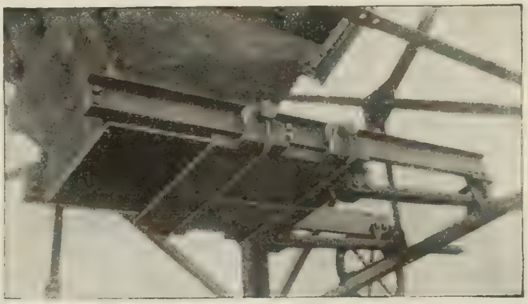


FIG. 5. CLOSE-UP VIEW OF DISCHARGE GATE

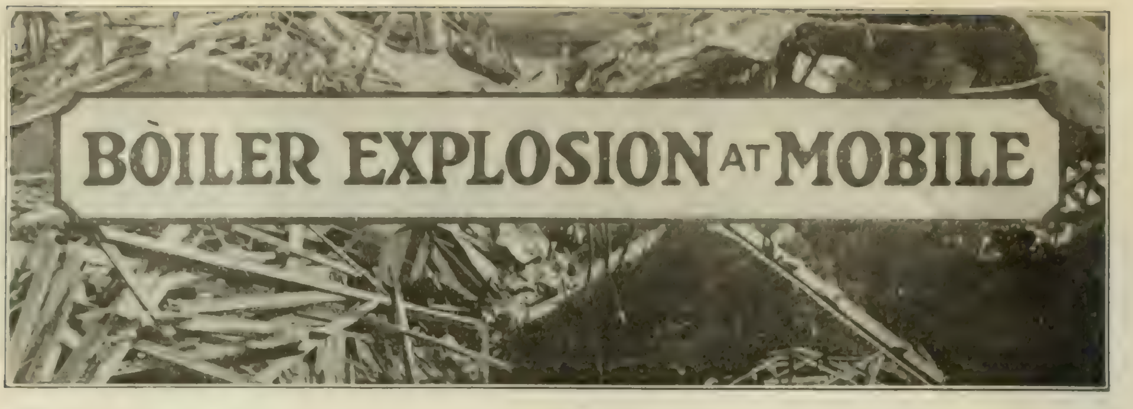
Sectional cast-iron plates make up the body of the hopper, which rests on a steel supporting structure of angle iron. This structure is built of standard steel sections cut and punched ready for erection and bolting. When it is in place the cast-iron plate supports are hooked upon the angle struts of the steel frame and into recesses in the sides of these supports are slipped the cast-iron side and corner plates. The plates and hooks are so constructed as to make tight joints.

At the bottom is a substantial hopper gate designed for quick discharge and large enough to offset any arching tendency of the material handled. The gate is mounted on rollers and is actuated by means of racks and a chain-operated pinion gear. The gate can be mounted so that the chain will come on any one of the four sides.

In the power plant the hopper is adapted for the storage of ashes, particularly from steam-jet vacuum conveyors, sized coal and screenings. In Fig. 1 the hopper is used for ash storage. Fig. 2 shows the supporting frame. In Fig. 3 the cast-iron side plates are being placed in position. Fig. 4 shows the corner construction and Fig. 5 is a close-up view of the discharge gate.

One of the outstanding advantages claimed for this hopper is the ease and quickness of erection. The frame is made of standard parts which are bolted together and the cast-iron plates are slipped into place, so that no skilled labor is required in the assembly work.

The rusting and corrosion of cast iron is negligible, and the comparatively thick metal in the plates resists the abrasive action of the material stored.



BOILER EXPLOSION AT MOBILE

ONE of the most disastrous boiler explosions in recent years occurred at the plant of the Mobile Electric Co. at Mobile, Ala., at 8:20 p.m., Friday, Feb. 21. This plant furnishes power and light for Mobile and vicinity. The total property damage, caused by the explosion and the fire that ensued, will be considerably in excess of $100,000. Three persons were killed at the time of the explosion, and one death has since occurred as a result of the accident.

The station is located at the intersection of Royal and St. Louis Sts., about three blocks from the business center of the city. That passers-by were not injured appears remarkable considering the violence of the explosion and the amount of material projected into the two thoroughfares. A pair of 12-in. I-beams 20 ft. long and two very heavy 15-in. I-beams 25 ft. long were thrown entirely across Royal St., one of these cutting off the corner of a foundation stone and being projected partly into a store on this street.

The plant was like those so frequently found where the capacity to be required was not anticipated in the original construction and additions had been made from time to time. This had resulted in a distinct division in the plant as regards both boiler equipment and generating units. One part was of modern construction with modern equipment. The old plant, the portion in which the explosion occurred, comprised the haphazard arrangement of apparatus incident to the unforeseen needs of development referred to. A solid brick wall 26 in. thick, pierced only by the necessary door openings, divided these two sections. The fact that this wall offered considerable resistance to the force of the explosion and presented, as well, a formidable fire barrier no doubt saved the plant from total destruction.

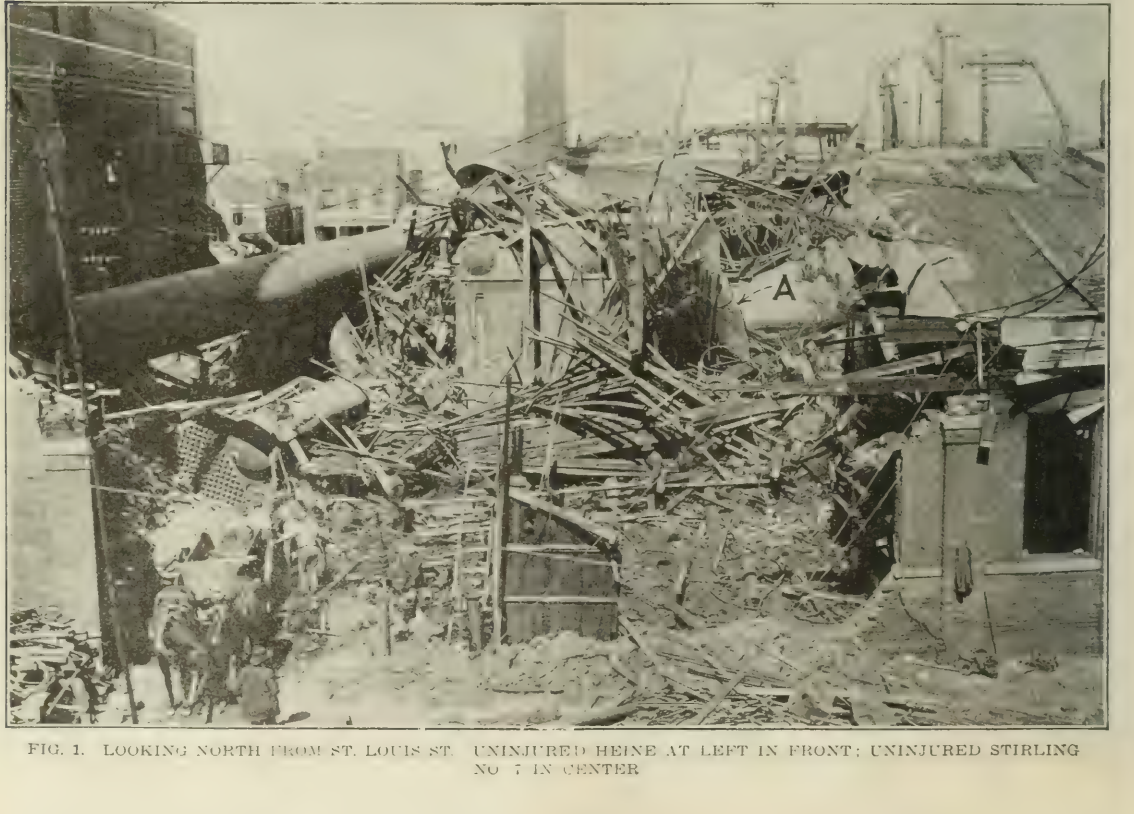


FIG. 1. LOOKING NORTH FROM ST. LOUIS ST. UNINJURED HEINE AT LEFT IN FRONT; UNINJURED STIRLING NO. 7 IN CENTER

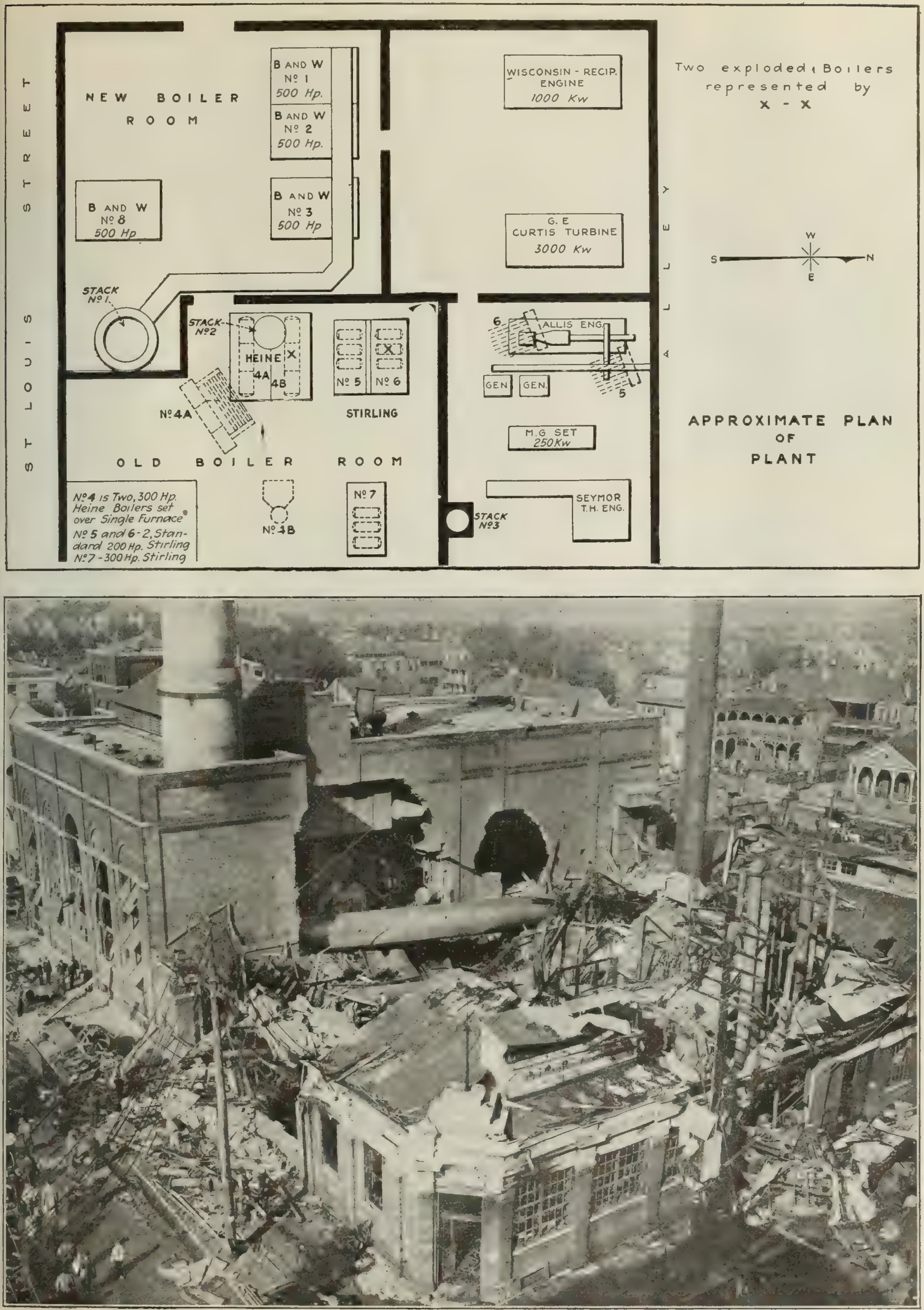


FIG. 2. PLAN OF PLANT AND GENERAL VIEW OF RUINS FROM THE CORNER OF ST. LOUIS AND ROYAL STS.

The accompanying plan, Fig. 2, shows roughly the arrangement of the principal units. In the new boiler room were four Babcock & Wilcox boilers, three of 500-hp. capacity, stoker-fired, known as Nos. 1, 2 and 3, and a detached boiler of the same type, of 600-hp. capacity, known as No. 8.

The boiler equipment in the old plant was composed of a pair of Heine boilers, containing 163 3½-in. tubes 18 ft. long with single 48-in. drums and two 200-hp. standard Stirling boilers containing 180 tubes each, known as Nos. 5 and 6. There was also a detached standard Stirling boiler, of 300-hp. capacity, known as No. 7, in the old plant. The two Heine boilers were set over one furnace and operated as a single unit, know as boiler No. 4. These boilers were connected on the steam side without the intervention of valves, but were not so connected below the water line. Each was supplied with a separate water column and fed as an independent boiler. At the time of the accident, boilers Nos. 5, 6 and 7 were not generating steam although still connected to the line, as the peak load had been passed and the fires under them were allowed to burn down. These boilers would probably have been disconnected from the line in a short time. The pressure as shown by the recording gage was just above 160 pounds.

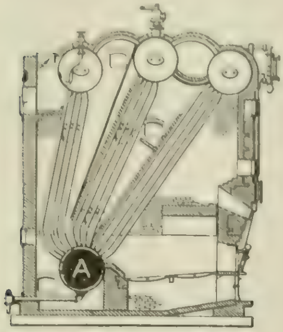


FIG. 3. STIRLING BOILER, SHOWING LOCATION OF RUPTURED HEAD

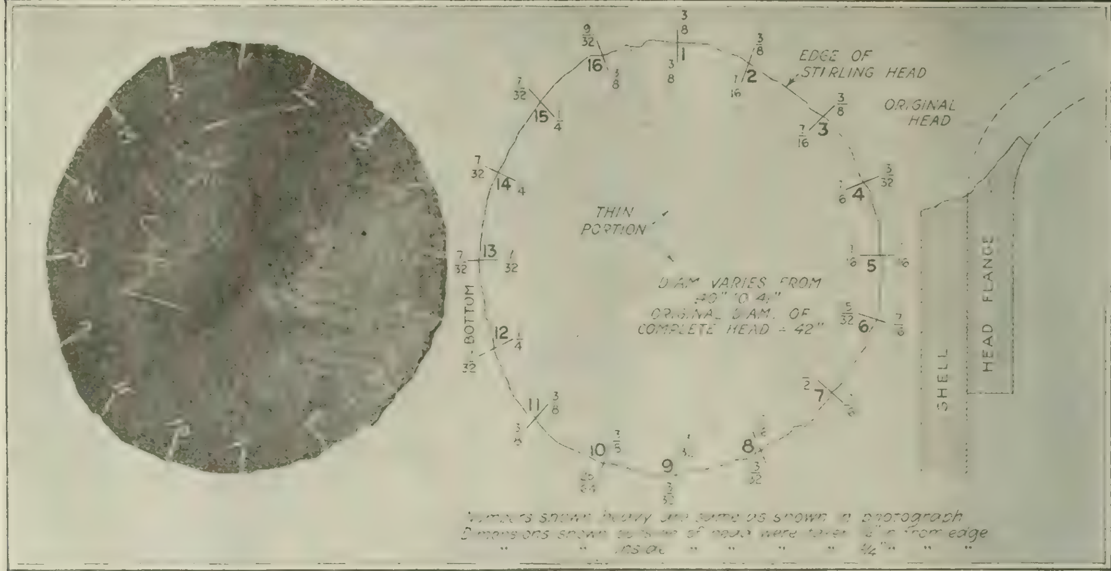

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
EDGE OF STIRLING HEAD
ORIGINAL HEAD
THIN PORTION
DIAM. VARIES FROM 40" TO 41"
ORIGINAL DIAM. OF COMPLETE HEAD = 42"
BOTTOM
SHELL
HEAD FLANGE
Numbers shown heavy are same as shown in photograph
Dimensions shown outside of head were taken from edge

FIG. 4. DISK FROM EXPLODED STIRLING MUD DRUM, SHOWING REDUCTION OF THICKNESS BY CORROSION. THE THIN PART WAS AT THE BOTTOM AS THE DRUM LAY IN THE SETTING

The two Heine boilers, No. 4, were also working light and the main part of the load was being carried by the B. & W. boilers in the new plant, with the exception of No. 3, which was being retubed.

The two stacks, shown on the plan as Nos. 2 and 3, in the old plant, were connected by a flue, so that either stack could serve all the boilers in the old plant or, by manipulating the dampers, the load could be divided between these stacks.

All boilers in the new plant were served by stack No. 1, which was of concrete; Nos. 2 and 3 were of plate steel. Only stack No. 2 was affected by the explosion, it being thrown down across the No. 5 and 6 Stirling boilers, as shown in the general view of the ruins, Figs. 1 and 2. The No. 7 Stirling boiler, in the old plant, was practically undamaged, although covered with débris, as will be seen in the center of Fig. 1, and also at the right end of the prostrate stack in Fig. 2.

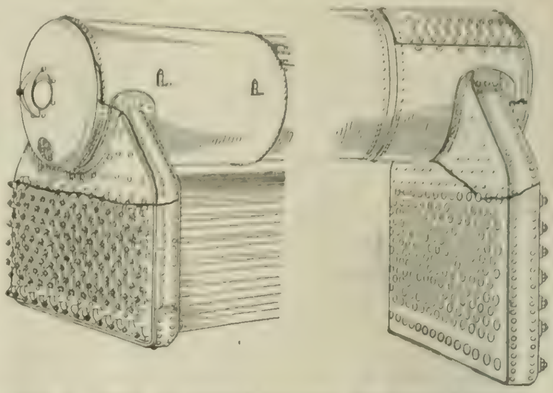
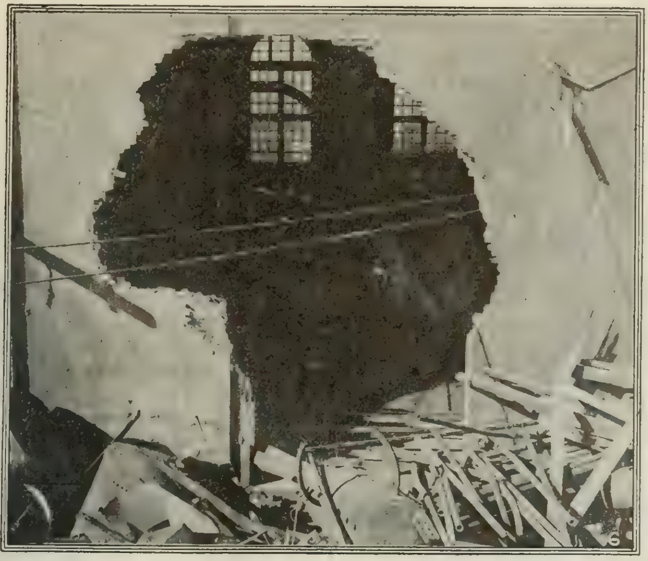
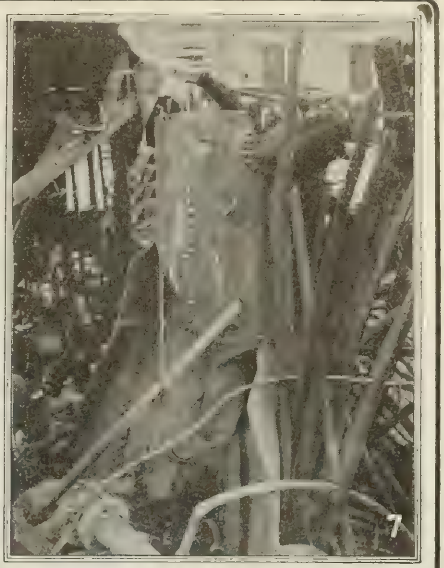


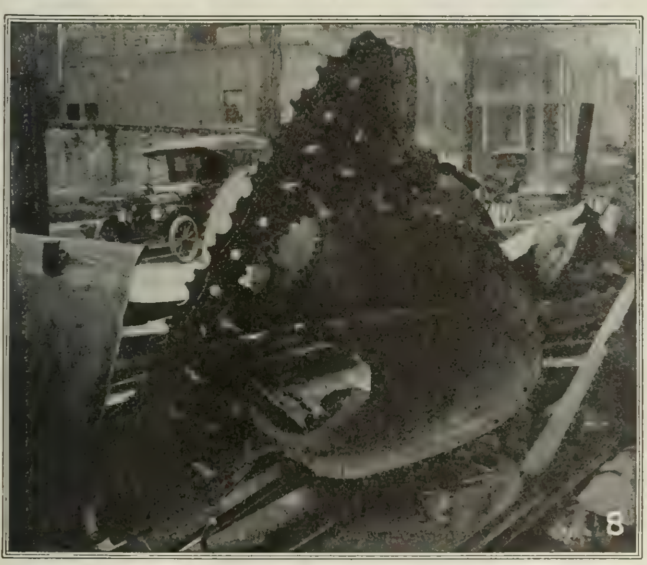
FIG. 5. REAR OF HEINE BOILER, SHOWING APPROXIMATELY THE LINES FOLLOWED BY THE FRACTURE

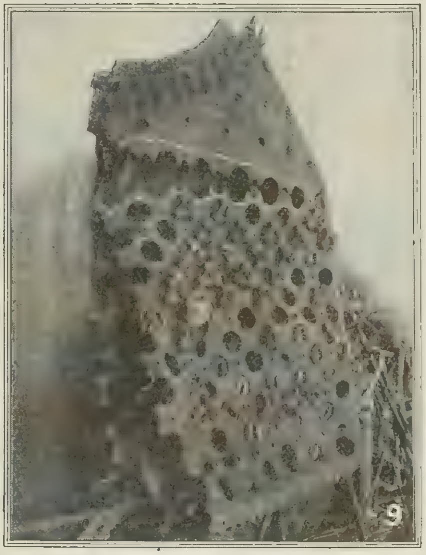
Two boilers exploded—the northern unit of the pair of Heines, No. 4, and the northernmost, No. 6 of the pair of Stirlings. These are indicated by X's on the plan, Fig. 2. The pressure carried was 160 lb. and the recording pressure gage showed that this had not been seriously exceeded.

The Stirling boiler was 22 years old. It failed by blowing out the head on the southern end of the lower









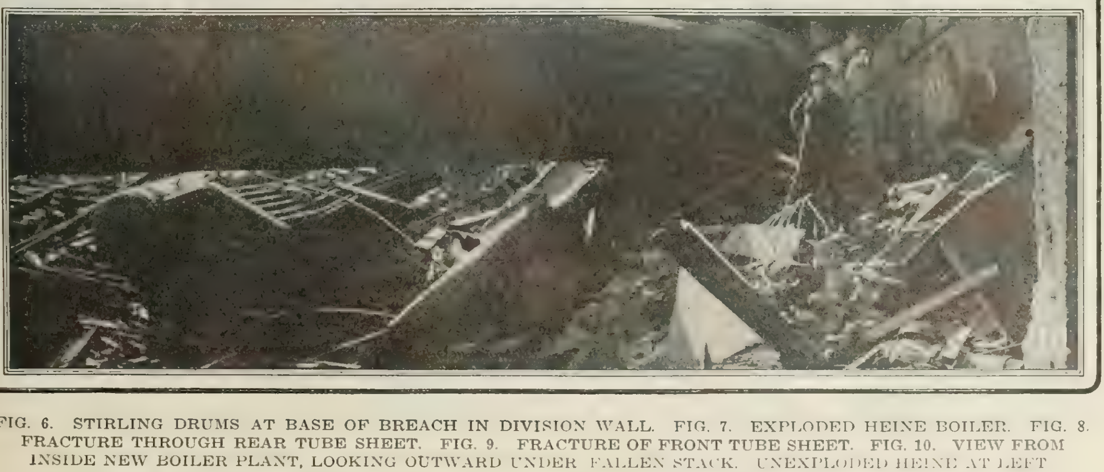


FIG. 6. STIRLING DRUMS AT BASE OF BREACH IN DIVISION WALL. FIG. 7. EXPLODED HEINE BOILER. FIG. 8. FRACTURE THROUGH REAR TUBE SHEET. FIG. 9. FRACTURE OF FRONT TUBE SHEET. FIG. 10. VIEW FROM INSIDE NEW BOILER PLANT, LOOKING OUTWARD UNDER FALLEN STACK. UNEXPLODED HEINE AT LEFT

or mud drum, the head marked *A* in Fig. 3. This was a 42-in. drum, and the head was unstayed but bumped to a radius of about 60 in. A disk broke out clean at the crown of the flange. Fig. 4 shows a photograph of this disk, and the sketch alongside shows the thicknesses as calipered one-quarter and three-quarters of an inch from the edge at the points indicated. The original thickness was less than would be required by the present A. S. M. E. Code, which would be five-eighths in. for 160 lb. if the radius of curvature of the head was 60 in. The code prescribes that the corner radius shall not be less than 1½ in. nor more than 4 in. and within these limits not less than 3 per cent. of the radius to which the head is bumped. We have not learned the corner radius in this case, and regret that no photograph was procurable of the ring of the flange out of which this disk was broken.

Fig. 2 shows two breaches in the eastern wall of the old station, the larger to the right of the concrete stack and the smaller still farther to the north. The No. 6 Stirling boiler stood in front of the smaller of these openings, which was evidently caused by its explosion. This boiler was projected to the north and landed on top of the 300-kw. Allis reciprocating unit. No. 5 Stirling apparently did not explode. None of the shells was ruptured, but a great many of the tubes had been pulled out of the drums and the drums had been separated from each other. They were projected in the same direction as those of No. 5. Some Stirling drums are shown at the base of the breach in the wall in Fig. 6, but it is not plain which of the boilers they came from. All of the Stirling drums, with the exception of that from which the disk shown in Fig. 4 broke out, were found intact. The closed head, that is the head without a manhole, of the mud drum of the No. 5 Stirling was in line with that which exploded and within a few inches of it in the division wall. This position made the inspection of these heads difficult and the determination of the corrosion by drilling impracticable. This head was found intact and not corroded. Inspection of the corresponding head in boiler No. 7 revealed corrosion, and a new head has been put in.

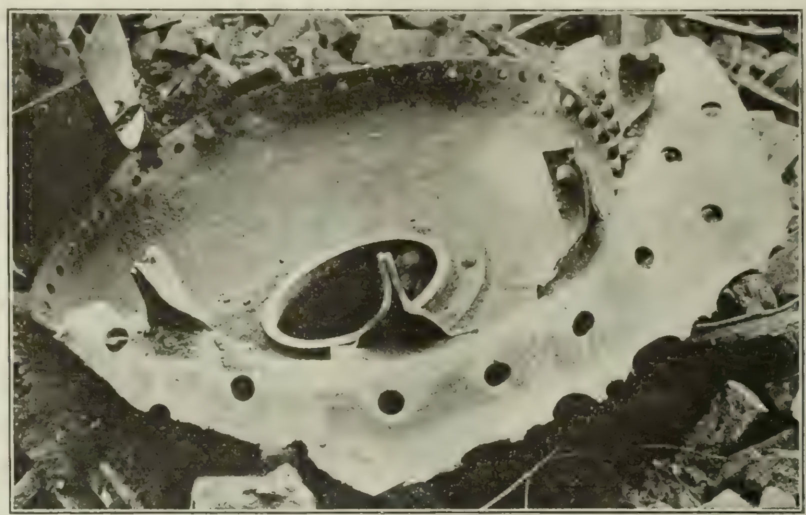


FIG. 11. REAR HEAD FROM HEINE DRUM, SHOWING BACKWARD BENDING OF THROAT SHEET AND THE WAY THE THROAT STAYS WERE TORN OFF

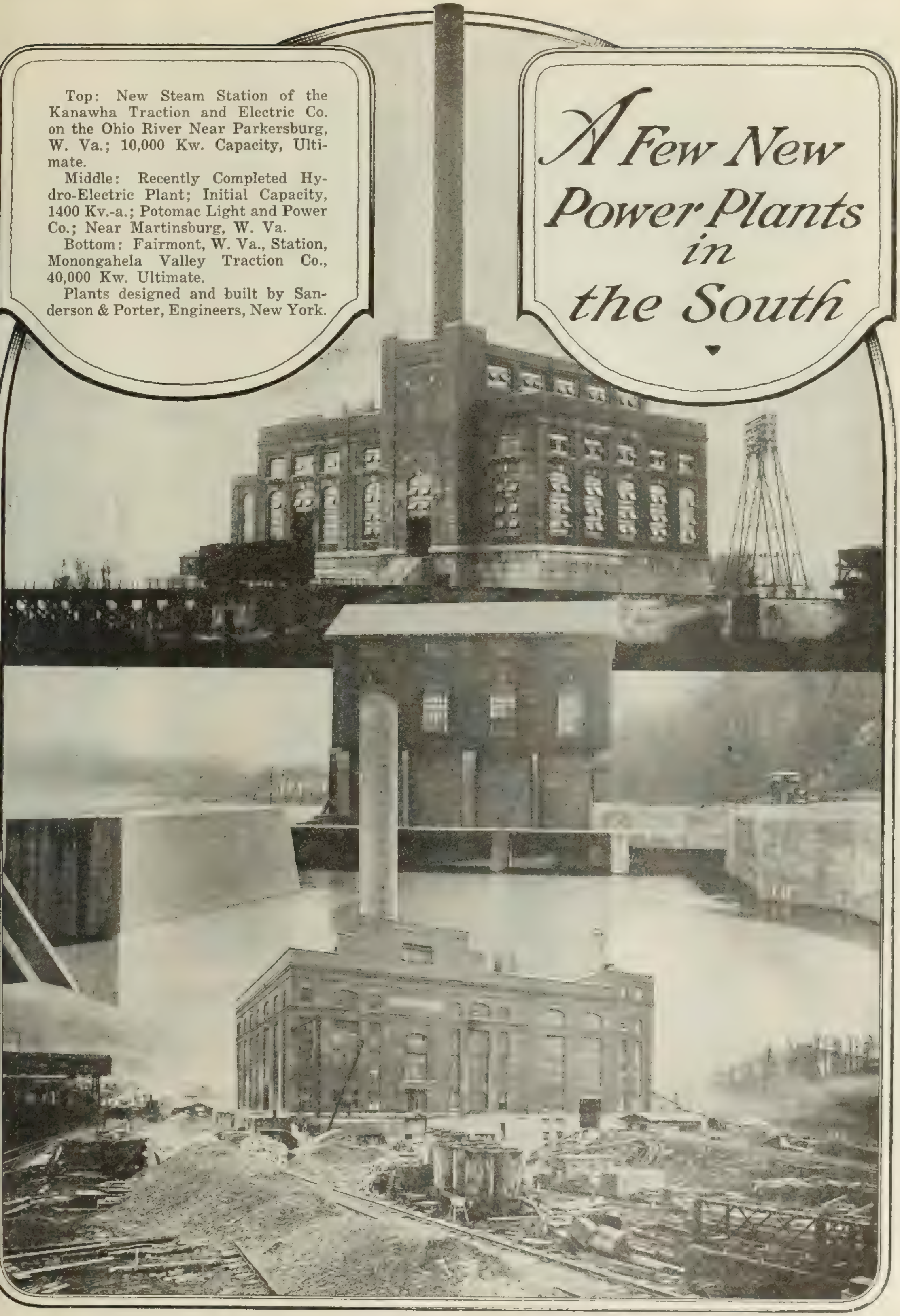
The northernmost of the pair of 15-year old Heine boilers, comprising Unit No. 4, exploded by breaking off the rear drum head and the back water-leg. The line of fracture passed through the tube holes, hand holes and adjacent stay-bolt holes of the upper row of tubes approximately as shown in Fig. 5. This water-leg was hurled backward against the division wall, evidently causing the larger breach, while the drum with the front leg and some of the tubes still attached was thrown forward and up-ended in the position shown at *A* in Fig. 1 just to the right, in that picture of the uninjured Stirling. The boiler, still in this position but viewed from the other side, is shown in Fig. 7 with a small portion of the rear water-leg attached, the end carrying the front water-leg being buried in the débris. The drum fracture runs through the solid sheet, passing through the girth seam without being diverted.

Fig. 8 shows the same piece viewed endwise after it had been removed to the side of the station. The fracture was along the line indicated by the chalk mark. Fig. 9 shows a portion of the front head after it had been cut away from the shell. Here the fracture is also indicated by chalk lines. There is no evidence of crystallization or corrosion in any of these fractures and the metal between the ligaments shows a good percentage of reduction. Some broken stay-bolts had been replaced six months before the explosion, but none was in evidence. The unexploded Heine was thrown to the left in the position indicated upon the plan, Fig. 1, lying as shown in Fig. 10, taken from inside the old station, looking eastward under the fallen stack. It was apparently injured only by the bending of some of its tubes and will be put back into service. Fig. 11, the rear head of the Heine drum, shows how the throat sheet was bent backward and the line followed by the fracture indicated in Fig. 5. The enlargement of the stay-bolt holes by the tearing out of the bolts is apparent. The throat stays broke in the shank, both through and outside of the rivets.

The necessity of getting the station back into operation led to the disturbance of much of the débris and the moving of parts the identification and location of which would have been of importance in determining the cause and manner of the explosion before expert observers had an opportunity to study their positions and fractures. Many of the pieces shown have been cut apart with the torch. For example, the piece shown in Fig. 9 is one-half of the front water-leg of the Heine. It had been removed from the position shown in Fig. 7, where it was attached to the drum and buried in the débris, and not only cut loose from the shell but cut in halves vertically. We have tried in such cases to indicate the original fracture by chalk lines.

There is much speculation as to which of the boilers let go first. Letters from the builders of both the Heine and the Stirling will be found on pages 465 and 466.

A Few New Power Plants in the South



Top: New Steam Station of the Kanawha Traction and Electric Co. on the Ohio River Near Parkersburg, W. Va.; 10,000 Kw. Capacity, Ultimate.

Middle: Recently Completed Hydro-Electric Plant; Initial Capacity, 1400 Kv.-a.; Potomac Light and Power Co.; Near Martinsburg, W. Va.

Bottom: Fairmont, W. Va., Station, Monongahela Valley Traction Co., 40,000 Kw. Ultimate.

Plants designed and built by Sanderson & Porter, Engineers, New York.

The APPALACHIAN POWER SYSTEM

By

H. S. Slocum,

MECHANICAL ENGINEER,
WITH
VIELE, BLACKWELL & BUCK,
CONSULTING ENGINEERS, NEW YORK.

Describes the chief features of the Appalachian Power Company's hydro-electric and steam system supplying electric current to a large section of the South.

THE southwestern part of Virginia and the southeastern section of West Virginia possess in large quantities such natural products as coal, manganese, zinc, iron, salt, limestone, alkalies, silica and gypsum. The great semibituminous or Pocahontas coal fields are here. Electrification of many of the coal mines has assisted in increased production, and, as this electrification uses water-power-generated electricity for the most part, which is produced more cheaply than the usual steam station can furnish it, conservation of the high-quality coal mined in the district is accomplished. Power is supplied this district by the Appalachian Power Co., which began development of two of its several power sites in 1911.

The hydro-electric developments are located on the New River, which rises in the northwestern part of North Carolina and flows in a general northerly direction through the States of Virginia and West Virginia. It drains the territory which has the highest altitude of any part of the country east of the Rocky Mountains and in which the annual rainfall is from 45 to 60 in. The drainage basin contains numerous springs and is heavily wooded.

The Appalachian Power Co. owns several hydroelectric power sites, two of which have been developed, and also controls a reservoir site above the power developments. The building of this reservoir and the consequent regulation of the river will greatly increase the output of hydro-electric power and improve operating conditions.

The two plants now developed are known as No. 2 and No. 4. They are about 50 miles southeast of the coal fields on a branch of the Norfolk & Western Ry. and have a combined rating of 30,000 hp. They are similar in design and the turbines are identical in size and characteristics, but run at different speeds to suit the different heads.

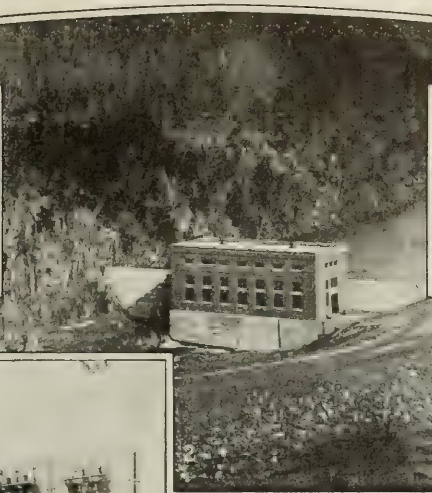
The substructures are of reinforced concrete and were the first of the improved concrete form scroll cases of the type which is now so generally used for medium and low head developments.

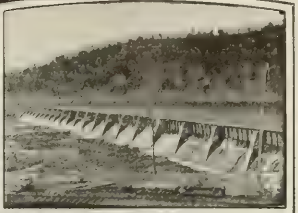
The spillway dams are of the ogee type of solid masonry. Provision has been made on the spillway sections of the dam for flashboards, and as the river rises very rapidly in flood times, a quick-acting catch holding the sections is used to insure a quick and positive release. To provide for ordinary freshets six motor-operated Tainter gates of standard type were installed on each dam.

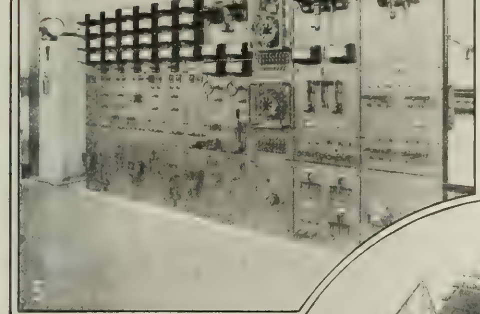
In conjunction with the main spillway dam at No. 2, there is an auxiliary spillway made by enlarging a natural channel and the ordinary flow shut off by a low barrier dam and flashboards of similar design to those of the main spillway. The power-house substructure forms part of the dam, and the waterways, including scroll cases and draft tubes, are formed in the concrete, into which are built the speed ring and pit liners. The runners are of cast iron and the turbines, which were guaranteed for 85 per cent. efficiency, at test showed a maximum of 93.7 per cent., which is probably the highest efficiency ever obtained in hydraulic-turbine practice.

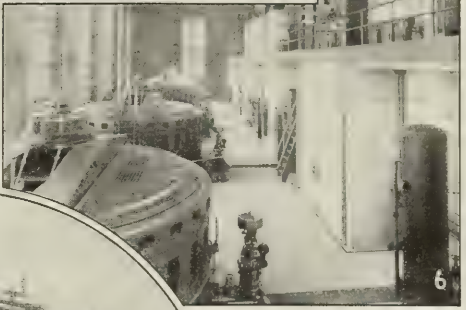
The generators are direct-connected through the vertical shaft to the turbines, and the weight of the revolving parts is sustained by roller and Kingsbury bearings on top of the generators. Governors are of the hydro-electric double floating-lever type, operated by high-pressure oil.

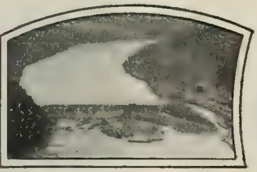
Exciters are the vertical type, of which there are two in each station. The power is generated at 13,200 volts and transmitted to the main transformer station, which is near No. 2 development. This transformer station was designed to take care of not only the two plants developed, but also the several additional plants

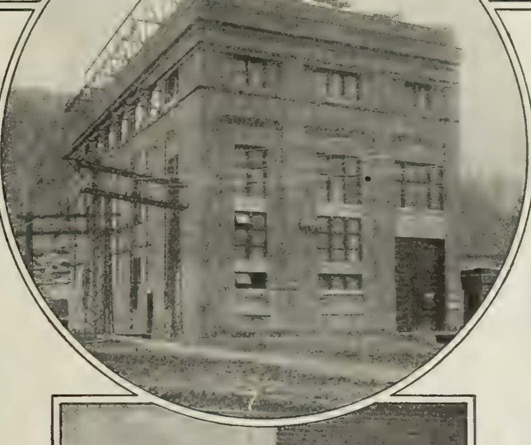


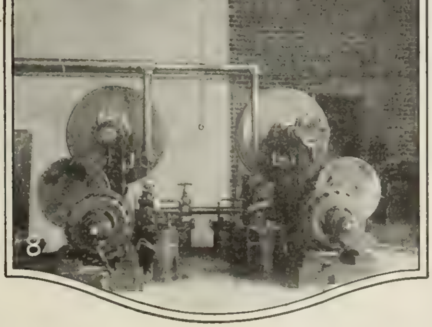












Some Views of the Plants and Equipment of the Appalachian Power System in Virginia and West Virginia. The 20,000-kw. Steam Station, Figs. 9 and 10, is part of the System. The Connected Load is about 50,000 kw. Power is Furnished to the Coal Mines of West Virginia.

Fig. 2. View of No. 4 Power House.

Fig. 3. Looking Down the Intake of No. 2 Power House.

Fig. 4. Spillway Dam, No. 4 Development.

Fig. 5. Switchboard in No. 2 Power House.

Fig. 6. Interior No. 2 Turbine Room.

Fig. 7. Step-Up Transformer Station.

Fig. 8. Pumps for the Governor System.

when they are built. The location is near the center of the present and future developments, and it is used as the central transforming and load-dispatching station. The electrical apparatus in the power house is simple and consists of low-tension busses, switches and station transformers, all of the high-tension apparatus being in the transformer station. The power is transmitted on duplicate high-tension lines at 88,000 volts and at 13,200 volts on the low-tension distribution lines. Two general styles of structures were used for supporting the lines. The single-pole, wishbone type, and the double-pole strain structures were used on the first lines, while in later construction two-pole structures were used throughout, with extra bracing for strain and angle structures.

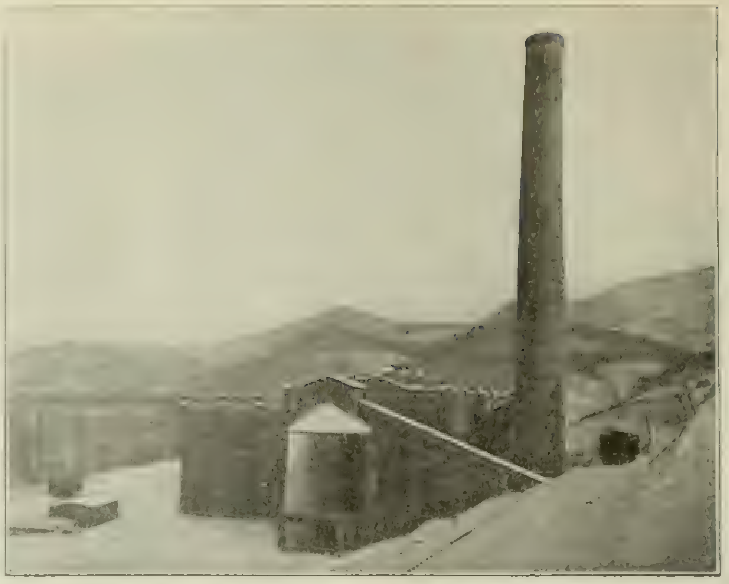


FIG. 9. THE NEW STEAM STATION AT GLEN LYN, VA.

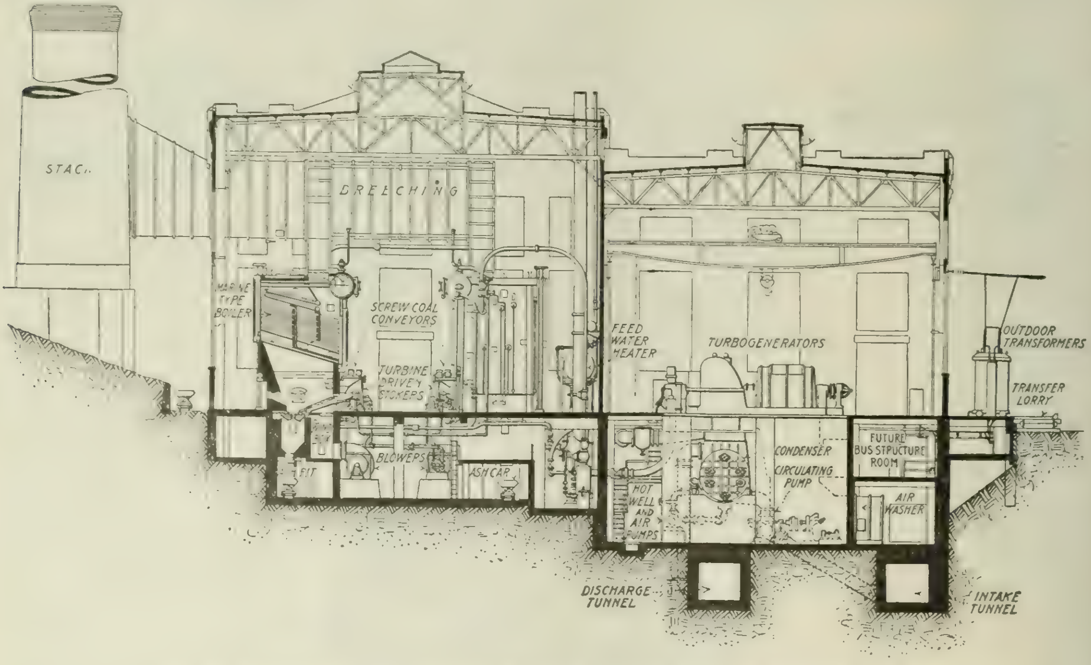


FIG. 10. SECTIONAL VIEW OF THE 20,000-KW. STEAM STATION AT GLEN LYN, VA.

Latticed steel poles designed to act as strain structures are used at all railroad crossings. Suspension-type insulators are used throughout, and telephone circuits are strung on the same poles. Both aluminum and copper conductors are employed. Throughout the territory served there are six high-tension substations with step-down transformers, high- and low-tension switching apparatus, lightning arresters, etc., from which the power is distributed to the consumer at 13,200 volts and to those near at hand at voltages suitable for their requirements. In conjunction with the hydro-electric plants the company operates several auxiliary steam plants, the largest of which is the Glen Lyn station.

Besides this auxiliary steam plant the system is interconnected with the Norfolk & Western steam station at Bluestone and the Roanoke Railway and Electric Co. at Roanoke.

The chief engineering data are given in the two accompanying tables, which cover both the water power and the steam stations.

Besides having several steam plants upon which to fall back when water power is insufficient, the company is interconnected with the Roanoke Railway and Electric Co. at Roanoke, Va., and also with the Norfolk & Western Ry.'s steam plant at Bluestone, W. Va. The latter connection is made through a frequency changer.

The total connected load of the Appalachian company system is approximately 50,000 hp. With scientific management the interconnection have made it possible for the power company to meet the unprecedented demand from the coal fields and industrial plants in all parts of the area. In 1917, however, in order to meet the rapidly increasing load and to do all possible to prevent the threatened coal shortage, the company decided to build an additional steam auxiliary plant. Such a station was decided on because it could be completed in a shorter period than a hydro-electric plant and furthermore, because it would permit the utilization of the maximum water-power and allow operation of the system at its maximum efficiency. In other words, it is intended to use as much hydro-electric power as possible without counting on storage, depending upon the steam auxiliary in times of low water. Later it is planned to build a third hydro-electric plant for the next source of power and follow this with another steam unit, and so on.

IMPORTANT DATA, APPALACHIAN WATER-POWER STATION

Main-Unit Turbines:	Power House No. 2	Power House No. 4
Head without flashboards	48.5 ft.	34.0 ft.
Number	4	3
Rated capacity	3500 hp.	6000 hp.
Type, Francis, single-runner inward-discharge, concrete formed scroll case		
Diameter of runner	7 ft., 6¼ in.	7 ft., 6¼ in.
Diameter of shaft	14½ in.	14½ in.
Operating speed	116 r.p.m.	97 r.p.m.
Specific speed	309	312
Guide bearings, Babbitt-metal lined		
Thrust bearings, standard roller and Kingsbury		
Exciter Turbines:		
Head without flashboards	48.5 ft.	34 ft.
Rated capacity	430 hp.	250 hp.
Type, Francis, single-runner, inward discharge, cast-iron scroll case		
Diameter Runner	2 ft., 3⅜ in.	2 ft., 3⅜ in.
Diameter shaft	4½ in.	4½ in.

Main Generators:

Dev. No. 4 type A.T.B. 74-2300-97-13,200-vertical internal revolving field, rated capacity, 2300 kv.-a. @ 97 r.p.m., 13,200 volts, 60 cycles.

Dev. No. 2, A.T.B. 62-4000-116-13,200 vertical internal revolving field, rated capacity, 4000 kv.-a. @ 116 r.p.m. 13,200 volts, 60 cycles.

Exciter Generators:

Dev. No. 2, M.P.C. 6-250-400-250 vertical revolving-armature type, rated capacity 250 kw. @ 400 r.p.m., 250 volts.

Dev. No. 4, M.P.C. 6-150-330-250, rated capacity 150 kw. @ 330 r.p.m., 250 volts

Main-Unit Governors:

Hydraulic type of oil pressure—double floating lever, for both developments.

Exciter Governors:

Hydraulic type of oil pressure.

Oil Pumps for Governor Oil:

Triple back-geared, motor-driven.

Main Gates:

Steel plate, built-up-roller, double-screw, motor-operated.

Crane:

50 ton, 4-motor with 10-ton auxiliary hook.

Main Step-Up Transformer Station:

Transformers, W.C.D. 60-6000-88,000-13,200 water-cooled oil-insulated type normal rating, 6000 kv.-a @ 88,000 volts delta on high-tension side; 13,20 volts on low-tension side 60 cycles.

High-Tension Switches:

K-10-110,000 volts solenoid-operated.

Lightning Arresters:

Aluminum-cell, electrolytic.

The construction of a 20,000-kw. station with an ultimate rating of 60,000 kw. was started in September, 1917, at Glen Lyn, Va., which site is the nearest of the coal fields at which an adequate supply of water suitable for condensing purposes was available. It has the additional advantage of being on the main lines of the Norfolk & Western Ry. and the Virginian Ry. Simplicity was the keynote of the design, ease and economy of operation and ample space for apparatus being other ruling considerations.

A coal siding leads from the Norfolk & Western main line to a point back of the boiler room. In the future another siding will run from the Virginian Ry. to practically the same point but higher in elevation. When desired, coal may be stored on the ground paralleling these sidings and rehandled by a locomotive crane.

From the cars the coal will be dumped into a steel track hopper and by means of plate feeder and grizzly fed to a crusher driven by a 25-hp. induction motor, all of which apparatus is housed in a reinforced-concrete building. The fine coal is taken by means of a Robbins belt conveyor, rated at 50 tons per hour, to a reinforced-concrete coal bunker of 800 tons capacity outside of the boiler room. The bunker proper is circular in form and has 12-in. very heavily reinforced walls. Crickets with a 45-deg. slope made of hollow tile for lightness, with a smooth concrete cover, lead the coal to the four bottom gates.

This type of bunker has several advantages over the bunker suspended in the boiler room: It permits of much lighter superstructure steel in the boiler room, allows an unobstructed passage for the breeching, makes a lighter, better-ventilated boiler room, and can be constructed without interfering with the erection of boilers and other apparatus at a time when the boiler room is necessarily much crowded.

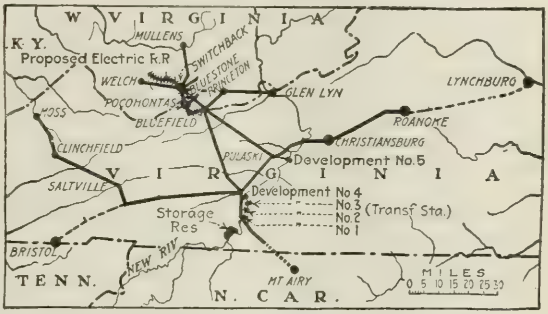


FIG. 11. DISTRIBUTION SYSTEM AND LOCATION OF POWER HOUSES

To convey coal from the bunker to the boiler furnaces use is made of four screw conveyors, each of them capable of delivering 25 tons per hour and driven by two 25-hp. adjustable-speed motors. More than one conveyor can serve each boiler, hence breakdown of one conveyor will not cripple a boiler. The motors and driving gear for the conveyors, also a small motor-generator set furnishing direct current for magnetic separators (used to clean coals), are housed under the wood structure covering the bunker.

The generator and boiler room floor was fixed about 6 ft. above the high-water mark of the year 1916, and the reinforced-concrete substructure was made with 10 per cent. of hydrated lime to make the walls impervious to water. Open drains will lead water which may seep through the walls to a sump in the power house from which it is removed by motor-driven centrifugal pumps. The superstructure walls are of hollow tile, which will be stuccoed when the next unit is added. Gypsum slabs were chosen for the roof on account of their lightness and heat-resisting properties. Skylights are provided in the boiler room in addition to windows.

At present four B. & W. marine-type, cross-drum boilers, having 12,322 sq.ft. of heating surface, are installed. They are designed for 300 lb. pressure and 200 deg. F. superheat and are steel-incased and insulated by ½-in. asbestos mill board and 4 in. asbestos blocks. The drums and top circulating tubes are insulated with asbestos. Independent steel columns are used for supporting the boilers, which are not attached to the superstructure steel in any way.

The marine type of boiler was primarily designed for maximum steam capacity in small space, with high rate of evaporation and high pressures. A longitudinal-type boiler of this capacity would require six drums, with corresponding multiplicity of joints and connections, greater headroom and higher cost.

Each boiler is served by a fourteen-retort Westinghouse stoker driven through gears by a steam turbine mounted on the boiler-room floor. Air to support combustion of the fuel is supplied by four turbine-driven conoidal fans each capable of delivering 50,000 cu.ft. of free air against 6½ in. static of water pressure. If found necessary, it is relatively simple to connect the windboxes of adjacent furnaces so that one fan can supply air to two units instead of one. The products of combustion are delivered through a steel-plate breeching (asbestos-covered) to a radial-brick stack with top 225 ft. above the grates.

The ashes are dumped into a firebrick-lined concrete pit under each boiler and by means of 1-cu.yd. metal cars and an electric hoist and telpher at the end of the building are taken to the yard and utilized at present for filling in the low places around the property. Later, the ashes will be deposited in a hopper and taken away by cars.

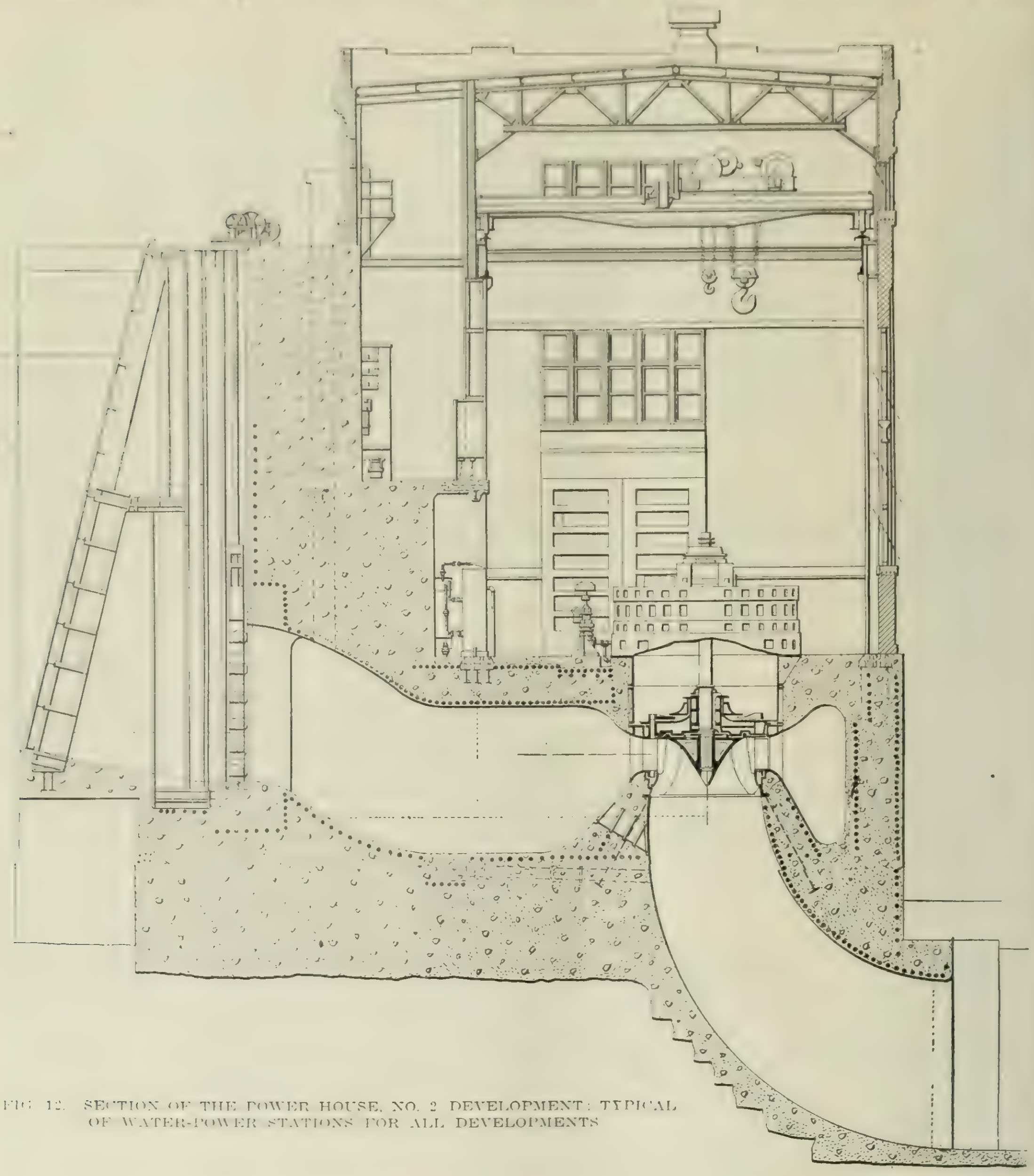


FIG. 12. SECTION OF THE POWER HOUSE, NO. 2 DEVELOPMENT; TYPICAL OF WATER-POWER STATIONS FOR ALL DEVELOPMENTS

A water-clarifying plant having a capacity of 4000 gal. of water per hour is used for treating boiler-feed water, which carries considerable matter in suspension during flood season. From the clarifying plant the treated water is taken by gravity to a clear-water well, and thence pumped into a feed-water heater which also receives the exhaust steam from all the auxiliaries. Since the plant is run at full load, practically all the time steam drive was used almost exclusively for auxiliary drive as the exhaust steam is fully utilized.

Condensing water is obtained from the New River, which, while furnishing an adequate supply, carries an unusual amount of débris at certain times of the year. As a result extra efforts have to be taken to prevent clogging of the condensers. To facilitate clearing away débris that collects in front of the intake mouth dupicate screens and hoists are provided so one may be cleaned while water is passing through the other. Stop logs may be inserted in grooves of the tower for cleaning tunnels when necessary.

As the plant is interconnected in a system with several sources of power, one turbo-generator was installed instead of two or more units of smaller capacity.

The switching apparatus and electrical equipment is

IMPORTANT DATA OF GLEN LYN STEAM STATION, APPALACHIAN POWER CO.

Location, Glen Lyn, Va., on New River, with spur track connections from N. & W. and Virginian R.R.

Station, main generating capacity, nominal kw. (present unit), 20,000; 60,000 kw. future.

BOILER ROOM

Width of firing aisle	25 ft. 1 in.
Type of boiler, B. & W. sectional cross-drum	Water-tube
Number of boilers (present unit)	4
Horsepower each boiler	1,232
Tubes: 42 header sections, 14 tubes, each 4-in. diam., 18 ft. 0 in. long	
Steam drums: One 60 in. x 29 ft., 10 in. long	
Six 4½-in. consolidated safety valves	
Two 4-in. feed-water inlets	
Four 2½-in. blowoff outlets	
Two 6-in. steam outlets	
Grate surface, sq.ft. (active)	246
Heating surface, sq.ft. (each boiler)	12,320
Heating surface per sq.ft. active grate areas, sq.ft	50.1
Heating surface per installed kilowatt normal capacity of generators	2.46
Working pressure, lb. per sq.in	300
Superheat, deg. F	250

BOILER PERFORMANCE

Boiler Horsepower	Boiler Rating, Per Cent.	Combined Efficiency, Per Cent.
1232	100	77.5
1850	150	76.0
2470	200	73.0
2810	228	70.0
3080	250	67.0
3700	300	60.0

Three-hr., 2-in. draft at damper temp., 650 deg. F. at damper

Stoker, Westinghouse underfeed (14 retorts to each boiler)	
Grate surface (active)	246 sq.ft.

Coal: Pocahontas, fixed carbon, 71 per cent volatile, 19 per cent moisture, 2 per cent. ash, 8 per cent. sulphur, 1.5 per cent. heating value (dry); 14,000 B.t.u.; as fired, 13,720 B.t.u.

BOILER AND FURNACE EFFICIENCY

Combined Boiler and Furnace Efficiency, Per Cent.	Per Cent. Boiler Rating
77	150
76	200
75	250

CAPACITY

Per Cent. Boiler Rating	Duration
300	24 hr.

PERFORMANCE DATA (ONE BOILER)

Boiler Rating, Per Cent.	Air per Min., 65 Deg. F. Cu.Ft.	Air per Min., 65 Deg. F. Lb.	Windbox Pressure, In. Water
150	19,000	1,440	2.5
200	25,500	1,930	3.2
250	34,000	2,570	4.3
300	44,000	3,330	5.5
...	50,000	3,780	

FAN CHARACTERISTICS

Cu.Ft. Air per Min.	Velocity Pressure, In.	4 In. Static, R.P.M.	Pressure, Hp	5 In. Static, R.P.M.	Pressure, Hp	6 In. Static, R.P.M.	Pressure, Hp.	7 In. Static, R.P.M.	Pressure, Hp.
29,550	0.202	843	33.6	925	43.0	1002	52.9	1075	63.3
36,090	0.302	875	40.5	956	50.7	1030	61.5	1101	72.8
42,650	0.422	909	48.8	989	60.0	1064	71.7	1131	83.9
49,210	0.560	953	58.7	1027	70.9	1099	83.5	1163	96.8

Stoker Drive: Connected by reduction gear and Morse chain to Westinghouse noncondensing turbine

Fan Equipment: No. 7½ D.W. turbo type conoidal fan connected through a flexible coupling and reduction gear to a Westinghouse noncondensing turbine

Capacity furnace ash hopper, each, cu.yd	33
Capacity ash, cars, each, cu.yd	1
Soot blowers, "Diamond," 12 units on each boiler	

Main steam valves, "Crane" cast-steel body with monel metal seats and stems

Automatic stop-check valves, "Crane" vertical

Blowoff valves, "Everlasting"

Feedwater heater, one "Cochrane" horizontal cylindrical, capacity 250,000 lb. per hr.

Feed-water pumps (two), Lea & Courtenay
- Type, 4 in., four-stage single-suction uniflow
- Capacity, 500 gal. per min. against 350-lb. pressure, or a total head of 810 ft. direct-connected to a two-stage noncondensing type L. G. E. turbine

Water clarifying: Booth, type F-T, electric-motor driven, purifying capacity, 4,000 gal. hourly; softener tank, 16 ft. 3 in. diam. by 16 ft. 0 in.; filter tank, 6 ft. 0 in. diam. by 6 ft. 4 in.

Chimney: One (present unit) 200 ft. x 16 ft. diam. at top; top 225 ft. above grates

Turbine (present unit) General Electric, 60 cycle, three-phase, 13,200-volt, 1800 r.p.m., 15,000 kw. @ 80 per cent. load factor; excitation, 100 kw. @ 125 volts, 40,000 cu.ft. air per min.
- Dimensions, including direct-connected exciter: Length 42 ft. 6 in., width 19 ft. 8 in., height 11 ft. 9 in., weight (net) 385,000 lb.
- Capacity per sq.ft. floor space covered by turbine (rated) .... 18.1 kw.
- Weight of turbine, lb. per rated kw 25.66
- Steam consumption per kw.-hr.; pressure, 250 lb.; superheat, 200 deg. F.; back pressure 1 lb. abs.; bar. at 1500 ft. = 28.75 in.

Kilowatt Output of Generators	Pounds per Kw.-hr.
7,500	11.45
11,250	10.75
14,000	10.45
15,000	10.50
18,750	10.80

Exciter: Direct connected to horizontal turbo-generator; Type M.P.C., poles 6, kw. 100; speed 1800 r.p.m., volts 125, field winding, shunt; amperes, 800

Ventilation: One Spray Co. air washer and cooler, capacity, 40,000 cu.ft. per min. motor, 440 volts, three phase, 60 cycles, 1800 r.p.m., 7.5 hp.; pump, 231 gal. against 70-ft. head

Condenser (present unit): Wheeler Condenser and Engineering Co.

Steam to be condensed per hour, lb	220,000
Condensing surface, sq.ft	30,000
Diameter of tubes, in. O.D	1
Length of tubes	20 ft. 0 in.
Gage of tubes, B.w.g	18
Circulating water, gal. per min	30,000
Circulating pump power, b.h.p	210
Circulating pump speed, r.p.m	280
Circulating pump turbine speed, r.p.m	2,800
Circulating pump turbine steam, lb. per hr	5,750
Circulating pump section, diam., in	30
Circulating pump delivery, diam., in	30
Circulating pump steam, diam., in	3
Circulating pump exhaust	6
Air pump speed, r.p.m	2,000
Air pump capacity of free air per min., cu.ft	45
Hotwell, in	5
Hotwell speed, r.p.m	2,000
Air and hotwell pump, turbine b.h.p	135
Air and hotwell pump steam per hour, lb	4,500
Steam power 250-lb. gage, 200 deg. superheat, 2 lb. back pressure	

Condenser performance: At 30 in. barometer (28.75 in. at Glen Lyn)

Pounds Steam per Hour		Temperature Circulating Water, Deg. F.	Vacuum, In. (30 In. Barometer)	Vacuum at Glen Lyn, In.
206,750 = 18,750 kw. @	11.00 lb	60	28.83	27.58
212,000	11.30	70	28.35	27.10
220,000	11.74	80	27.75	26.50
275,000	14.65	80	27.00	25.75

Transformers: Three single-phase, water-cooled, 60-cycle, 6250-kv.-a. outdoor-type transformers 88,000/13,000 volts, 11,800/12,400/13,650 volts taps
- Efficiencies: Full load, 98.7; ¾ load, 98.7; ½ load, 98.5
- Weight Transformers: 29,300 lb., oil, 12,200 lb.; total, 41,500 lb.
- Dimensions: Height over bushings, 17 ft. 11¼ in.; over cover, 13 ft. 6¾ in.; length, 7 ft. 11½ in.; width, 4 ft. 8½ in.
- Water required at full load, 23 gal. per min. per transformer at 25-lb. pressure

Switchboard equipment:
- One T.P.S.T. H-6 1200 amp. 15,000 V. tandem bottom connection oil-circuit breaker
- Two T.P.S.T. K-22 150 amp. 110,000 V. outdoor type oil-circuit breaker
- Four 150 amp. bushing-type current transformers and two operating solenoids
- Six S.P.S.T. 90,000-volt 300-amp. outdoor-type disconnecting switches
- Three S.P.S.T. 15,000-volt, 1200-amp. L.G.-16 indoor-type disconnecting switches with
- Three three-phase solenoid control relays
- Two three-phase, 90,000-volt outdoor-type aluminum-cell lighting arresters
- Six 90,000-volt, 300-amp. choke coils, control circuits, 125 volt from storage batteries

Oil-filtering System: No. 6 Peterson, capacity 400 to 600 gal. per hr.; pump, 1-in. Taber rotary, motor-driven, ⅓ hp., 440-volt, three-phase, 60-cycle, 1,200 r.p.m.; overflow gage simple, although it will be more elaborate in the future, after more units are added. The 13,200-volt generator leads run direct through a 15,000-volt 1200-amp. H-6 automatic motor-operated oil circuit-breaker to the main transformers, which are installed outdoors and rated at 6000 kv.-a., 13,200/80,000 volts each. Taps from these leads are taken through a disconnecting switch and a 15,000 volt, 300-amp., K-2 automatic hand-operated oil-circuit breaker to a bank of 100-kv.-a. 13,200/440-volt outdoor-type transformers which supply energy for station motors. Another set of transformers supply energy for station lights. The high-tension circuits run from the main transformers through a 110,000-volt, 150-amp., K-22 nonautomatic solenoid-operated oil circuit-breaker, also installed outdoor. Lightning arresters, choke coils, etc., are employed as usual. The arrangement of switches mentioned and illustrated makes it possible to feed back from the line in case the generating unit is shut down and also to furnish power for the auxiliaries at times when power is shut off the transmission line. Owing to the fact that there is but one unit, no low tension bus is needed, but space has been provided for concrete cells, which will be built when the station is extended. The outside switching arrangements are temporary, being intended for the present installation only. When the extension is added provision will be made for other outgoing lines, when a steel structure will be built. No reactors have been provided for this installation as it was thought that the length of line would cushion any disturbances that might occur. However, they will be provided when the next unit is added.

A 30-mile electric transmission line connects this plant with the system at Switchback, W. Va. A telephone circuit is carried on the same poles.

The plants were designed and constructed by Vielé, Blackwell & Buck, 49 Wall St., New York, and the writer was in charge of the work at Glen Lyn and engineer on construction of the hydro-electric stations.

A Progressive Cotton-Mill Community

THE progress made by the South in the textile industry during the last decade is exemplified very satisfactorily by a group of cotton mills at LaGrange, Ga. A little more than ten years ago the Unity Cotton Mill was the only one of the present group in existence. A few years later the Elm City Mill was built; this was followed by the Unity Spinning Mills, and the latest addition to the group is the Hillside Mill, which was built in the latter part of 1915.

The power plants of this group of mills do not embody any radical features or startling innovations; they merely represent substantial, high-grade engineering as judged in the light of cotton-mill practice at the dates when the mills were built. The power-plant equipment of the Hillside Mill consists of seven horizontal return-tubular boilers, 78 in. by 20 ft. each, and an 1800-hp. cross-compound engine, which drives most of the mill through the conventional rope drive. The steam plant is supplemented by alternating-current motors in one or two departments, these motors being served from the transmission lines of the Columbus Power Co.

The power plant is somewhat unusual in the fact that no reciprocating pumps are used. The boiler-feed pump is a turbine-driven centrifugal. It takes water from the bottom of the hotwell, where it is comparatively still and less likely to be contaminated by oil, and delivers it to the boilers through a closed feed-water heater; the temperature of the water at the boiler inlet ranges from 200 to 205 deg. F.

The condensing equipment consists of a 30-in. barometric condenser and a turbine-driven centrifugal circulating pump. With supply water at 80 deg. F., this outfit maintains a 26-in. vacuum when the engine is developing 2400 hp. The water from the hotwell is cooled by means of spray nozzles.

The power-plant equipment of the Unity Spinning Mill consists of 800 hp. in horizontal return-tubular boilers, a cross-compound engine of 750 hp. and 250 hp. in electric motors taking current from the Columbus Power Co.'s transmission line. The condensing equipment is of the barometric type with a spray-nozzle system for cooling, as in the Hillside plant.

The power plant of the Elm City Mill comprises four horizontal return-tubular boilers of 250 hp. each and a cross-compound engine of 800 hp. The condensing system at this plant consists of a surface condenser and the usual pumps.

The Unity Cotton Mill equipment is of the ordinary type in vogue ten or twelve years ago.

The Hillside Mill equipment consists of 30,000 spindles, 700 looms and a corresponding outfit of pickers, carding machines, etc. The mill employs 1400 operatives and turns out 10,000,000 lb. of ducks and specialty fabrics per annum.

The Unity Spinning Mill contains 14,700 spindles and turns out 3,640,000 lb. of yarn annually for the knitting trade, fire-hose and automobile-tire trades.

The Elm City Mill contains 11,664 spindles and 138 looms; its annual output is 4,000,000 lb. of heavy duck.

The Unity Cotton Mill operates 11,000 spindles and 150 looms; the annual output is about 3,600,000 lb. of duck.

This group of mills is situated in a settlement known as Southwest LaGrange, just outside of LaGrange proper. This settlement has been developed according to the most modern ideas of scientific welfare work. At each of the mills there is a Martha Washington Inn, with clean, wholesome accommodations for the "unattached" female operatives and a Ben Franklin Inn for the men. A flourishing library and a Y. M. C. A. organization, a thoroughly up-to-date school system and several churches supply the moral, mental, spiritual and physical needs of the community. There is also a well-equipped hospital, and an agricultural department which includes a large greenhouse. A feature of the Y. M. C. A. that might profitably be emulated by other similar organizations is a systematic exercise period of thirty minutes before work hour in the morning. The men and boys gather on the athletic field and engage in ball-throwing, football kicking and other moderate stunts which tend to eliminate foggy brains and flabby muscles.

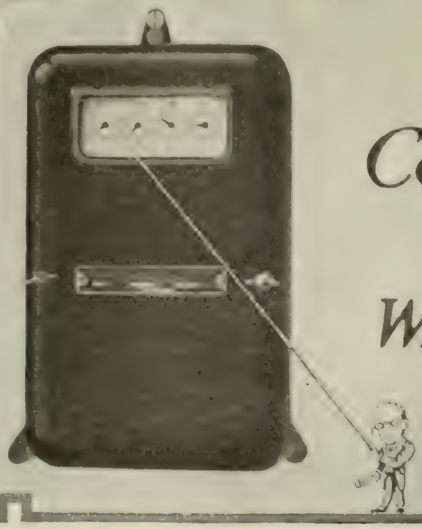
The founder of this community and the man whose ideas have directed all the features of its development is Fuller E. Calloway. Mr. Calloway has a positive genius for organization and an uncanny knack in the selection of executive lieutenants.

COTTON MILLS
at La Grange, Georgia.

Back View of Hillside Mill

Elm City Mills

Unity Spinning Mill



How to Correctly Read A WATT-HOUR METER

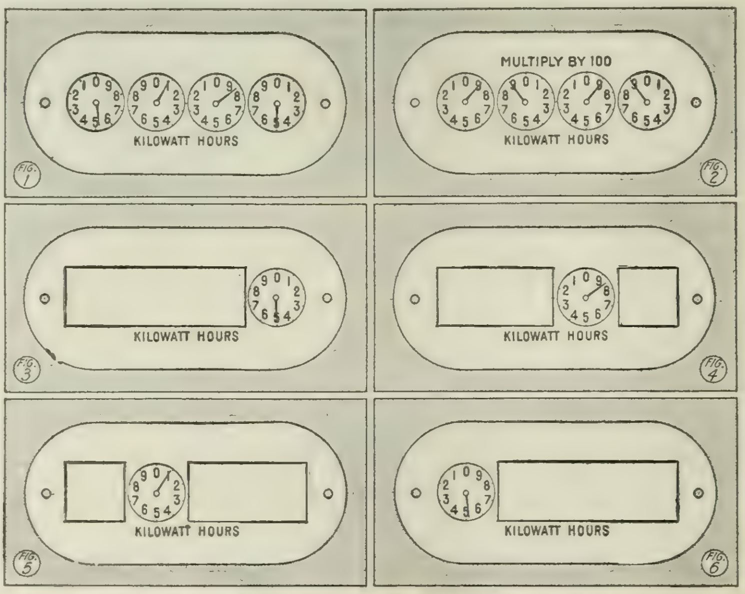
By

Victor H. Todd

Gives the different forms of dials used on various makes of watt-hour meters and explains how to read them. The chances for making an incorrect reading due to misplaced hands on the dials or failing to use a constant are pointed out.

IN VIEW of the essentiality of the watt-hour meter to produce accurate records, it is often called the cash register of the operating company, for it determines the revenue that the company should receive from the sale of electric power. For this reason it is, or should be, very accurate, and this accuracy is often maintained by elaborate and expensive tests and standards. Not only should the meter be accurate, but it must also be read correctly. If the error is in the consumer's favor, it means an actual loss of revenue to the company, and if in the company's favor, a loss to the consumer unless he checks the meter each time it is read. For this reason the consumer should learn to read the watt-hour meter, and check the meter reader every time a reading is taken. The reading of a watt-hour meter is often attended with the idea, by the inexperienced, that it is a difficult task and requires considerable experience, when in fact quite the reverse is the truth; therefore it is the purpose of this article to present the subject in such a way as to meet the need of those not familiar with the reading of a watt-hour meter.

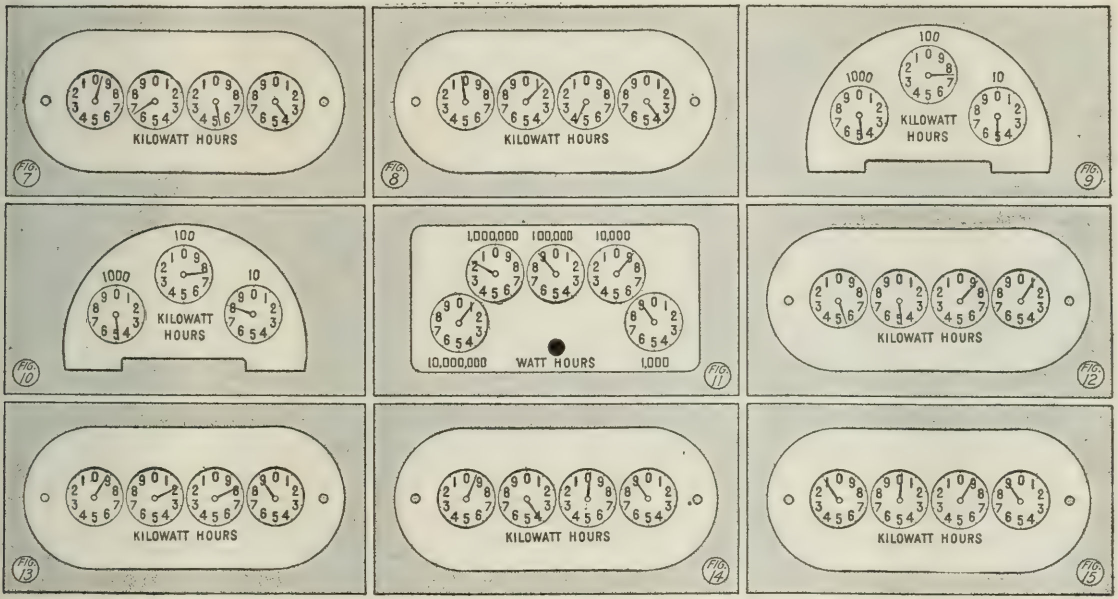
The standard dial face for watt-hour meters adopted by the National Electric Light Association is similar to that shown in Figs. 1 and 2. Previous to this standardization each manufacturer had his own style of marking the dial. But outside of the actual variation in the arrangement, the number and marking of dials on watt-hour meters of various makes, the underlying principle is the same. The rotating element is carefully adjusted by various means so that it rotates at a definite speed, proportional to the power transmitted in the circuit which it is measuring. This element is geared to a train of gearwheels which moves the pointers, or hands, proportional to the product of the watts or kilowatts and the hours, which is called watt-hours or kilowatt-hours. One kilowatt-hour is equal to 1000 watt-hours. The dials are all arranged with a 10



FIGS. 1 TO 6. INDICATE HOW TO READ A WATT-HOUR METER

to 1 ratio; that is, any pointer or hand moves ten times as fast as the pointer of the dial to the left. In other words, it takes ten revolutions of the fastest-moving pointer at the extreme right to equal one revolution of the next pointer to the left. It takes ten revolutions of the second dial pointer from the right to make one revolution of the third dial pointer, and so on. Another way of expressing it, is to say that one revolution of the fastest moving pointer will equal one division, one-tenth of a revolution, on the next dial.

It will also be noticed from the figures that where one pointer rotates in a clockwise direction the next turns counterclockwise, and so on. The sequence of the numerals clearly shows in which direction the pointer is rotating.



FIGS. 7 TO 15. SHOWING SOME DIFFERENT STYLES OF WATT-HOUR METER DIALS

Fig. 7—Four-dial, reading 9654. Fig. 8—Four-dial, reading .0144. Fig. 9—Three-dial, reading 475. Fig. 10—Three-dial, reading 478. Fig. 11—Thompson, five-dial, reading 1,188,900 watt-hours, or 1188 kilowatt hours. Fig. 12—Misplaced hand on second dial; apparent reading 5481, correct reading 5491. Fig. 13—Misplaced hand on second dial; apparent reading 9189, correct reading 9179. Fig. 14—Misplaced hand on third dial; apparent reading 9499, correct reading 9399. Fig. 15—Misplaced hands on second and third dials; apparent reading 1099, correct reading 0989.

The generally approved method of reading a watt-hour meter is from right to left; that is, read the fastest-moving dial first, then the next, etc., and set the figures down from right to left as noted from each dial. As a typical example, take the dial shown in Fig. 1. Hold a piece of paper over the three left-hand dials and consider only the extreme right-hand or fastest-moving pointer as shown in Fig. 3. It tells two things: First, that the last number in the reading is 5 unless there is a constant, as explained later, and second, that the next pointer, although it cannot be seen, must be halfway between two numbers, 0.5 of a division. Therefore the number 5 is jotted down, and the position of the pointer on the next dial mentally noted, then the second dial is inspected, as in Fig. 4. The pointer is found to be halfway between 8 and 9. Now it cannot be 9 because the pointer has not yet reached 9, so the lower figure (8) is jotted down, making the last two numbers 85.

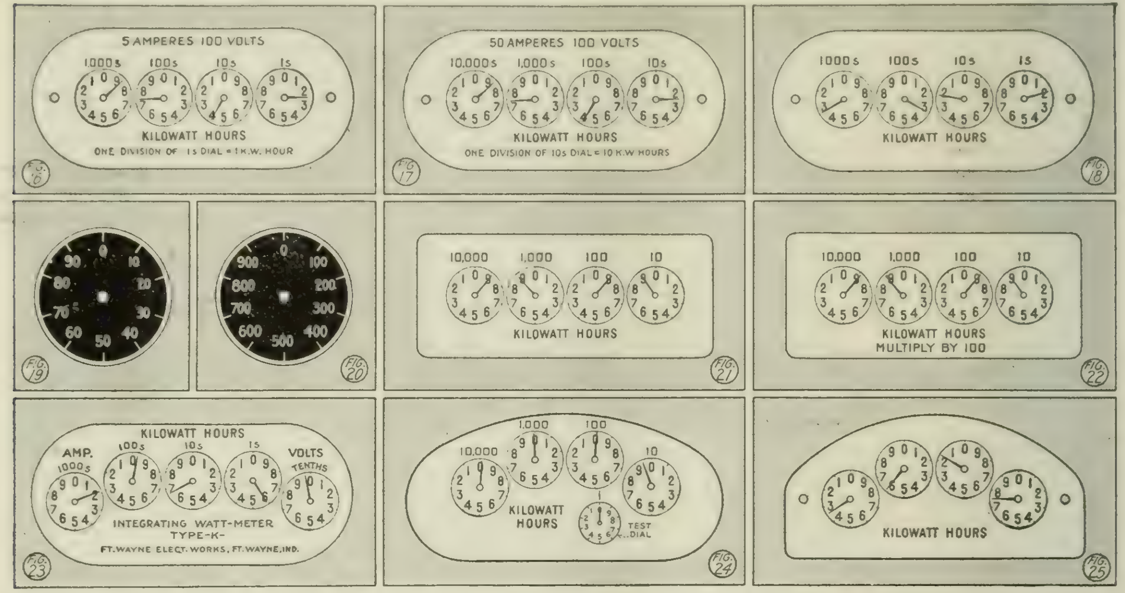
This second dial also tells that the third pointer has almost reached a number, 0.8 of a division, although as yet the number is unknown. An inspection of Fig. 5 shows that the pointer has almost reached 1, but as the preceding dial says it has not yet reached 1, therefore the lower numeral (0) must be used, making the last three numbers 085. This also shows that the next unknown dial to the left, has just passed a numeral, which is found to be 5 by referring to Fig. 6, consequently 5 is set down, making the total reading 5085.

Now this does not mean that the consumer has used 5085 kilowatt-hours; it simply indicates that the meter has recorded that much since it started to run. To get the consumption of power or kilowatt-hours for a definite period, it is necessary to have the reading or indication at the beginning of the period and at the end. The difference between the two readings will indicate the actual amount of power used. These readings may be taken month after months and the reading at the end of one period may be taken as the reading at the beginning of the next.

When the reading at the end of a period is less than at the beginning—that is, when the slowest-moving pointer has passed zero, as for instance in Figs. 7 and 8, where Fig. 7 gives the reading (9654) at the beginning of the period, and Fig. 8 gives the reading (0144) at the end of the period—the total consumption of power is obtained by placing the numeral 1 in front of the last reading and subtracting as in other cases. For instance, the reading, Fig. 8, at the end of the period would be 10,144 instead of 0144. Subtracting 9654, Fig. 7, from 10,144 gives the power used as 490 kilowatt-hours. After the reading is taken at the end of the next period, the reading 0144 is used. Multiplying 490 by the rate per kilowatt-hour gives the cost. In this case, if the rate is 10c. per kilowatt-hour, then

490 × $0.10 = $49. If the rate had been 6c. per kilowatt-hour, the bill would be 490 × $0.06 = $29.40

Some makes of meters have five dials and some only three. The five-dial meter is satisfactory, although one dial is entirely unnecessary. Five-dial meters generally read in watt-hours instead of kilowatt-hours and the fastest dial is generally disregarded. The three-dial meters should not be used, as there are numerous cases where the slowest dial makes more than one complete revolution in a period. An example of this is shown in Figs. 9 and 10. The reading at the beginning of the period was 475, and at the end of the period was 478. Apparently, the consumer had used only 3 kilowatt-hours, and was billed accordingly. But the fact was, that the last dial had been completely around, and 3 kilowatt-hours more, so the actual amount was 1003 kilowatt-hours instead of only 3.



FIGS. 16 TO 25. SHOW SOME MORE DIFFERENT STYLES OF WATT-HOUR METER DIALS

Fig. 16—Westinghouse, type C, 4 dial; reading 8742. Fig. 17—Westinghouse, type C, 4 dial; reading 87,420. Fig. 18—Fort Wayne, 4 dial; reading 3322. Figs. 19 and 20—Slickers to indicate constants to be used. Fig. 21—General Electric, 4 dial; reading 8889. Fig. 22—General Electric, 4 dial; reading 888,900. Fig. 23—Fort Wayne, 5 dial; reading 1965.9. Fig. 24—Sangamo, 4 dial; reading 9999. Fig. 25—Fort Wayne, 4 dial; reading 3617.

In reading the five-dial meter, Fig. 11, the first right-hand dial may be neglected since one revolution of its pointer indicates only 1000 watt-hours, or 1 kilowatt-hour, which can be read directly from the second dial from the right. A complete revolution of the second dial indicates 10,000 watt-hours, the third 100,000 watt-hours, the fourth 1,000,000 watt-hours, and the fifth 10,000,000 watt-hours. Dividing each of the values by 1000 gives 10, 100, 1000 and 10,000 kilowatt-hours respectively. This is the same as the standard four-dial meter in Figs. 1 and 2, therefore may be read the same as explained in Figs. 3 to 6. The second pointer from the right, Fig. 11, will be read 8 and not 9, since the pointer on the first dial has only reached 9 and will have to be on 0 or pass it before the second dial will be reading 9. The third-dial pointer also reads 8 for the reason that the second-dial pointer has not reached 0 but is slightly back of the 9. Hence the reading of the second and third dials is 88. The fourth pointer indicates 1 and not 2, since the pointer on the third dial has not reached zero yet. This gives 188 as the reading of the second, third and fourth dials. On the fifth dial the pointer is slightly past 1, thus the meter reads 1188 kilowatt-hours. If the reading of the first dial is taken it is 900 watts, or 0.9 of a kilowatt-hour. Adding this to the reading of the other four dials gives 1188.9. But as before stated, the reading of the first dial is usually neglected and the reading is in this case taken as 1188 kilowatt-hours.

Reading a watt-hour meter would thus be very simple were the hands or pointers always correctly placed; but owing to careless placing, loose hands and excessive lost motion between gears, a pointer may have passed a number before it actually should or be behind a number when it should be ahead of it. For this reason, the dial to the right must always be consulted first. Look at Fig. 12. A quick, careless reader would say immediately 5481, taking as usual the lowest numbers. But the first dial on the right by pointing to 1 clearly indicates that the next pointer has passed a number, and as the second pointer says it is not quite 9, it is very evident that the hand is misplaced and is slightly back of its true position and should be a little in front of 9. So the correct reading would be 5491, a difference of 10 kilowatts.

As another example, take the dial shown in Fig. 13. A quick reading would be 9189, but a careful inspection will show that the first dial on the right. by indicating 9, clearly shows that the hand on the next dial has not quite reached a number, and as the next hand has actually passed the number, it is evidently misplaced and the true reading is 9179.

In Fig. 14, unless care is taken, the reading would appear to be 9499. But on examining the second dial it is seen that the pointer has not reached zero, where it would have to be for the pointer on the third dial to be on 4. But in this case the pointer has passed 4 when it should be slightly back of it, hence the pointer on the third dial is misplaced ahead of its true position and the correct reading is 9399, a difference of 100 kilowatt-hours.

On the dials Fig. 15 the reading of the hands appears to be 1099, but a careful inspection will show that the pointers on the second and third dials are misplaced. The pointer on the second dial apparently indicated 9, but on looking at the first dial it is seen that this pointer has not reached or passed 0, hence the pointer on the second dial is misplaced ahead and its correct position is slightly back of 9, so this dial's reading is 8 and not 9. On the third dial the pointer has passed zero, but this cannot be true because the pointer on the second dial has not completed its revolution, but, as pointed out in the foregoing, should be slightly back of 9, therefore the pointer on the third dial is ahead of 0 when it should be behind it. Then, since the pointer on the third dial has not reached 0, the pointer on the fourth dial cannot be exactly on 1, and the reading is not 1099 but 0989.

By far the greatest number of mistakes and costliest errors are made, however, by not using a constant or multiplying number when it should be used. When a large amount of power is being measured, it is impracticable to run the hands fast enough to indicate kilowatt-hours direct, so the gear trains are arranged to read 0.1, 0.01 or 0.001 of the correct amount, consequently the reading must be multiplied by 10, 100 or 1000 to get the true power consumed. In the standardized meters this number is marked on the dial as shown in Fig. 2, where a note says, "MULTIPLY BY 100." Therefore the reading, instead of being 8889, must be multiplied by 100, making the correct reading 888,900 kilowatt-hours.

The dial Fig. 17 very plainly states the value of one division on the first dial, where a note says, "ONE DIVISION OF 10S DIAL = 10 KW.-HOURS." In other words, if the pointer on the 10S dial moves from 1 to 2, it shows that 10 kilowatt-hours have been used, therefore every time the figure indicated by the last dial is set down, it must be followed by a cipher, so the reading on Fig. 17 would be 87,420 and not 8742, which is the correct reading in Fig. 16.

Other makers simply mark the dial 1S, 10S, 100S, etc., and leave off the note, but this simply means that 1 division from 1 to 2, or from 2 to 3, or from 5 to 6, etc., is the value by the letter "S." For instance, in Fig. 18 the reading is 3322 kilowatt-hours, but in Fig. 17 the first dial is marked 10S, meaning that each division is 10 kilowatt-hours and the reading is 87,420.

Others simply have the dials marked 10, 100, 1000, etc., in which case the number is the value of one complete revolution and not one division. Some central-station companies, realizing the great danger of misused constants due to lack of uniformity, use a little red sticker, similar to that in Fig. 19, and on any meter which is marked multiply by 10 or has the last dial marked "10S" they paste this little sticker on the dial. If it is marked "Multiply by 100" or "100S," the sticker shown in Fig. 20 is used. Its vivid color forcibly calls attention to the fact that the last number is more than 1 or 2 or 3, etc.

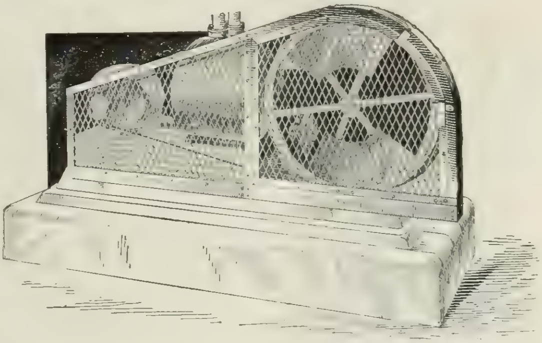
Another important point to watch is whether the dial is marked in watt-hours or kilowatt-hours. Figs. 11 and 21 show this. Fig. 21 reads in kilowatt-hours, but Fig. 11 reads watt-hours. Fig. 22 is the same style dial as in Fig. 21, but in the former a constant of 100 is used, therefore where the reading Fig. 21, is 8889 kilowatt-hours, in Fig. 22 it is 888,900.

If a meter has a dial like Fig. 23, the last dial is generally disregarded, the hand removed and a black sticker pasted over the figures. The test dial shown in Fig. 24 is also disregarded in computing the kilowatt-hours; it is for the tester's convenience only. Fig. 25 gives another arrangement of dials that read kilowatts. The dials are similar to those shown in most of the other figures, but are arranged around in a curve.

Thus it will be seen that there is a great liability to error through wrong reading or unused constants, and it is manifestly absurd to attempt to increase the revenue of a central-station company or keep accurate records of power consumption in different departments of an industry by maintaining a high meter accuracy, and then allow all kinds of errors in wrong readings.

"Steelcrete" Machine Guards

In many states the law demands that gearing, pulleys and various moving machinery shall be guarded in a suitable manner. Various methods are employed, such as railings, wire screens, guards, etc. A filling material for machine guards, known as "Steelcrete Mesh," is manufactured by the Expanded Metal Engineering Co., 8 West 40th St., New York City.



"STEELCRETE" GUARD AS APPLIED TO A MACHINE

Steelcrete mesh is cut from sheet plate steel and is pulled into a fabric of diamond-shaped meshes, the diamonds being joined at their "bridges" by short sections of the unsheared plate. This material is so tough that openings may be cut to any shape without weakening the guard and there is no danger of the strands separating. It also is capable of withstanding hard usage, and although a blow may dent it or even fracture one or more strands, the damage will not spread. Neither does it loosen up and sag nor disintegrate if a strand is broken.

No special tools are required to fit the guard in place, as the flat sheets are easily cut to fit the angle of the iron frame to which the mesh is attached with either rivets, bolts or spot-welding. The mesh is made in several sizes of diamonds and of various weights of material.

Operation of HOLTWOOD

By Charles H. B[illegible]

Instructing the Power House Crew

HOLTWOOD is on the Susquehanna River about fifteen miles from Lancaster, Penn., and about forty miles in an air line from Baltimore. This station was described by the writer in *Power* for May 13, 1913, at the time of its completion. The power house and dam are of concrete construction, the dam being approximately 2370 ft. long and 53 ft. high with a base width of 65 ft. At present the station has a hydraulic capacity of 118,500 hp. in eight units with generators rated at 83,500 kw. All but unit No. 8 have double draft tubes. The station originally was laid out for 10 turbines of 13,500 hp. capacity each with generators of 7500 kw. continuous rating, and five waterwheels of such capacity were installed, but at that time the owners found that units of 17,000 hp. could be installed without alteration of the pits, and when pits Nos. 6, 7 and 8 were to be used turbines of 17,000 hp. were ordered. The last unit installed, that is No. 8, has a single draft tube. The generators send their current to the transformers at 11,000 volts, at which point it is stepped up to 70,000 volts for transmission to Baltimore and to Lancaster. The Susquehanna is a widely fluctuating river. In times of high water there may be a flow of 400,000 cu.ft.-sec., and during low water the flow may drop as low as 400 cu.ft.-sec. There is no seasonal storage available. Fig. 5 shows an interior view of the turbine room. All important instructions to the crews are in writing and from the office of the chief operator. The orders are numbered and the sheets bound. Two volumes of instructions are in current use; namely, permanent instructions and current instructions.

This is the first of several articles that treat of operation and methods in the large hydroelectric station of the Pennsylvania Water and Power Co. at Holtwood, Penn., on the Susquehanna River. This article deals with the methods used in the instruction of the crew.

Permanent Instructions—These are in the nature of general rules to guide the crew. Several copies are issued, the floorman having one in his desk on the turbine-room floor; the switchboard operator also has one. A copy is kept in the office of the chief operator. When an employee has read and understands the rules and instructions he signifies to this effect by signing his name and the date on the last sheets of any particular set of instructions. This applies also to current instructions. At periodical intervals instructions of a permanent character are taken from current instructions and bound in the permanent instructions book. Bulletins or current instructions when superseding conflicting orders in the permanent instruction book, make specific references to such orders. In addition to the two sets of instructions a bulle-

UPPER PICTURE: CLASS OF OPERATIVES RECEIVING INSTRUCTIONS IN OPERATION OF AN OIL SWITCH. LOWER PICTURE: THE LIBRARY AT THE CLUB FOR THE POWER-HOUSE CREW AT HOLTWOOD tin board is provided. Ignorance of the rules and instructions is not accepted as an excuse for noncompliance. When instructions are not understood, the person to whom they are not clear inquiries of his superior for interpretation. All employees are periodically examined as to their knowledge of the permanent instructions concerning their work. The book of permanent instructions is made up of chapters on the following: General Station Rules, Safety Rules, Normal Electrical Operation, Abnormal Electrical Operation, Normal Hydraulic Operation, Abnormal Hydraulic Operation, Holtwood Records and Forms, Duties (this last chapter is devoted to the duties of each employee), Holtwood Hydraulic Maintenance and Electrical Maintenance. A sectional view of the station is shown in Fig. 3.

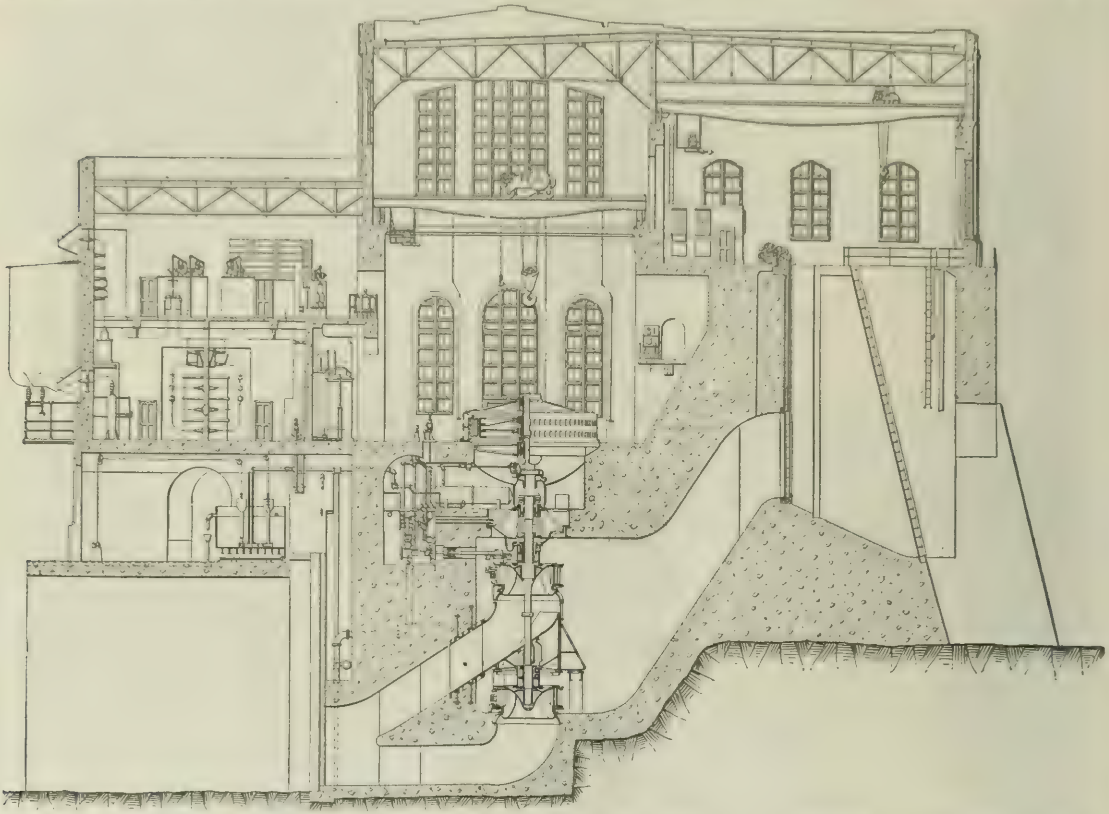


FIG. 3. SECTIONAL VIEW OF THE PENNSYLVANIA WATER AND POWER CO.'S STATION AT HOLTWOOD, PENN.

Working hand in hand with these instructions is the promotion system, according to which promotions are given on merit and not on seniority.

The company has provided a library in the clubhouse near the plant, and a large assembly hall, used for moving pictures, theatrical and social entertainments and also for lectures by outside speakers. A room in the station is fitted for lectures by heads of departments. Wide-arm chairs on which to lay note paper are used by those attending the lectures. Whenever possible, lectures are given with the actual apparatus discussed on view in the turbine room when such apparatus is conveniently portable. See Figs. 1, 2 and 4.

Serious troubles are reported in full, and when a discussion of these troubles, their causes and means of prevention is of value to the crew, the analysis and discussions are made by the man most competent and the reports bound and made available to all employees interested.

Excepting for the highly trained men, such as switchboard operators, testing engineer, chief operator and assistants, a hydroelectric plant when starting up depends upon the natives of the towns nearest the plant for help; that is, for cleaners, governormen, pumpmen floormen, machinemen, etc. A green man entering the employ of the company at Holtwood is started as a cleaner. As he progresses he is promoted in the following order: Cleaner, extra governorman, second pumpman, governorman, floorman, machineman, assistant operator and operator.

When the green man begins, he is given a sheet which tells him what are his duties. He is encouraged to learn as much as possible about the work of the rank next highest to his own, to which he will be promoted if fit. The assistant chief operator uses a loose-leaf book knows as "Progressive Standards of Advancement." In this he has a number of questions relative to the duties and mechanism in care of the various grades of men just mentioned. Periodically, he questions the men on the operation, care and maintenance of equipment in their charge and that in charge of the men in the next progressive position. This examination not only keeps the men studious and attentive to their work, but enables the management to soon discover the deadwood, and to be just in promotion, which, as stated, is solely on merit. The examination is an excellent check upon the operation in general. It reveals if the foreman or superior in charge of the man examined has instructed him as he is supposed to do; it shows that perhaps circumstances of load and shifts have given the man no opportunity to perform work which he should know how to do. For example, a governorman in the earlier part of his career may not have had occasion to cut in or out a turbine for several weeks owing to the load conditions during his watch. In such cases arrangements are made to have him do this in a day or two from the time that it is known that he has not had opportunity to do this work for some time.

The most sought-for opportunities for gaining practical experience of value are those when the station is operating under abnormal conditions, such as lightning, frazil ice run, etc. This is the time when the previously acquired knowledge is put to the real test for proper observation, correct diagnosis and quick action. Men off shift are permitted to come to the station at such times, either actually assisting under the orders of the operator in charge, or merely as observing witnesses, for their own benefit. In either case, they are paid their regular wages while volunteering outside of their regular shift hours.

FIG. 4. LECTURE ROOM AT THE CLUB

FIG. 5. INTERIOR VIEW OF TURBINE ROOM

"Progressive Standards of Advancement" is in many respects a unique bit of literature and practice. It forms primarily a basis of study for all operating employees, covering practically every important description and operating feature. The questions are divided into sections: First, General Station Knowledge and Theory; second, Demonstrations; third, Specific Questions. These last cover comments on disturbances to regulations, interruptions and tests of station apparatus. The first section applies only to foremen, machinemen, assistant operators and operators.

The comments on disturbances and interruptions cover such subjects as Frazil Ice, Assistant Operator's Mistakes at Highlandtown Substation, Lightning-field Relay Trouble, Foremen's Mistakes, Sleet Trouble on Baltimore System, Cable Failure Followed by Trouble between Stations, Voltage Disturbance Caused by Failure of Pipe Fitting in Governor Pressure System, Efficiency Tests of Turbines. The foregoing are typical of the literature available to the men. Each report or comment analyzes the cause of the trouble, tells what should have been done, what mistakes were made and the probable causes why they were made.

There follow a few typical questions in the examination of some of the men in the various positions; the questions are from *Progressive Standards of Advancement:*

Generator Cleaner—Demonstrate the starting of No. 3 air compressor.

Demonstrate the starting and stopping of a unit on hand control.

Enumerate the duties of extra governorman (this is the position to which the cleaner will be promoted).

How many pumps are there on the governor-control system?

Demonstrate sawing a piece of metal with a hacksaw.

Demonstrate cutting serviceable threads on a $\frac{3}{4}$-in. pipe.

Extra Governorman—What is the color scheme for the piping in the station?

What is the code used in whistle signaling?

Demonstrate reading an oil-meter dial.

Demonstrate changing a unit from hand control to governor control and vice versa.

Demonstrate cleaning screens in the water supply line to No. 8 turbine.

Explain the safety rules relating to the hydraulic section of the station.

Demonstrate the operation of the headgate winches.

Pumpman—What is the oil flow in gallons to all bearings on turbines and generators?

Sketch on the blackboard the central pumping system, governor and hand-control connections.

What precautions are to be observed in the pump tunnel in case of ice trouble?

Sketch on the blockboard the lubricating oiling system.

Why is the governor-control system divided into two distinct sections?

FIG. 6. FLOORMAN'S DESK ON TURBINE-ROOM FLOOR

Explain what you would do after a section of piping on the governor control system had failed due to the bursting of a fitting or the blowout of a gasket.

In the event of serious station trouble, which section of the station must first have concentrated attention to restore service?

Governorman—Demonstrate the least possible time required to start a unit from standstill to normal speed without overshooting, at the same time synchronizing with the bus.

How do you know from observation from the floor which unit is carrying the Lancaster load?

Calculate the volume in gallons of the No. 1 hand-controlled sump tank.

Demonstrate raising No. 3 headgate without assistance.

Locate all pump-motor circuits on the direct- and alternating-current power board.

In the event of disturbance, to which main unit should governormen first give their attention? Why?

Demonstrate the opening or closing of one or more transformer neutral ground disconnectors, as given by instructions from operator.

Floorman: How would you continue operation of the station in the event of failure of both direct current and alternating currents to operate the lubricating-oil pump motor?

What is the safe permissible temperature rise in the Kingsbury thrust bearings?

How are the alkalinity and acidity of the governor fluid determined?

Demonstrate the inspection of a governor-regulating valve.

Discuss the types of turbines in the station.

Explain precautions necessary in winter to prevent the 12-in. drainage-pump suction line from freezing.

Discuss the turbine-efficiency test report No. 19.

Machineman—Enumerate the machineman's duties during trouble.

Explain the function of the arc extinguisher relays and the principle of operation.

Make a one-line diagram of the generator and transformer windings and of the type or method of connection.

Diagram the connections to No. 2 governor pump.

Demonstrate the operation of the benchboard and the telephone exchange board.

Diagram the control connections of a General Electric and of a Westinghouse oil switch.

How is the presence of frazil ice in the forebay detected?

Demonstrate synchronizing generators with the bus.

These are a comparatively few of the questions asked. The machineman's examination is made the most thorough of all because a good machineman will invariably make a good operator. The questions asked of the assistant operator and operator are many and varied. The operator is called upon to understand the hydraulic section of the station as well as the electrical section, transmission lines, telephone lines, substations, etc. He is in charge of station operation and has authority over all operators, electrical and hydraulic.

Machinemen in training are sent to the various substations and spend about two weeks learning about the converters, rectifiers, etc., their operation and care. The training of employees at Holtwood is much more thorough than at any other power station the writer has ever visited. Fig. 6 shows the floorman's desk.

One of the striking examples of the value of instruction of the crew and practice by them to establish teamwork is the record time for bringing a main turbine from standstill to running in parallel with the bus. Turbines are brought up to speed on hand-control and when in parallel changed over to governor control. The record time is 26 seconds.

The cheapest method of obtaining nitrogen products for explosives or fertilizers is to procure them from the ammoniacal liquor and gas resulting from the carbonization of coal or its gasification in byproduct gas producers.

The Electrical Study Course—Testing Balancer Sets on Three-Wire Systems

Sets forth the tests to be made on balancer sets when placing them in service for the first time to ascertain whether the connections have been made to obtain the same direction of excitation in both machines.

IN THE preceding lesson the subject of starting balancer sets was treated of. There are, however, some additional points to be observed when such a set is put into service for the first time after being installed, that are worth being discussed.

In the case of shunt machines it is merely necessary to test out the direction of rotation of the two machines and to make the direction of both the same if found to be opposed, but for compound machines the further precaution must be taken that will assure the correct direction of current through the series fields.

The direction of rotation of shunt machines can readily be checked in the following manner: The connections having been made as in Fig. 1 and the switches S_N and S_L being open, the resistance of the field rheostats R_1 and R_2 is all cut out. A piece of wire is then connected as a short-circuit around one of the armatures as indicated by the dotted line C at the armature of G_1. The switch S is closed and the starting switch is then moved momentarily to the first contact, and the direction of rotation of the machines is observed and noted. The short-circuiting connection C is then removed from the armature of G_1 and placed across that of G_2 instead. The starting switch is again closed to the first contact and the direction of rotation of the set noted. If the direction in both cases is the same the machines are ready for service, but if the directions are opposed the field connections of one of them must be reversed. Doing so will change its direction of rotation, since the direction of the current through the armatures remains unchanged. Thus, to reverse field F_1 lead *b* would be transferred from *f* to *n*, and lead *d* from *n* to *f*, or to reverse field F_2 lead *c* would be changed from *g* to *n* and lead *e* from *n* to *g*. It is immaterial which field is reversed since the direction of rotation may be either way.

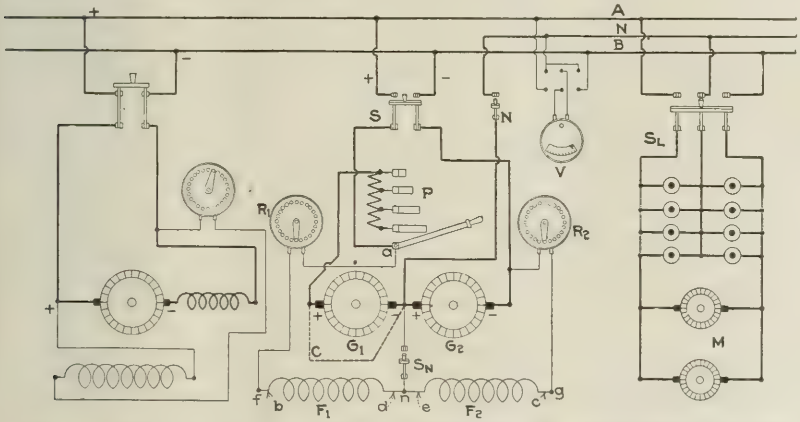


FIG. 1. CONNECTIONS FOR SHUNT BALANCER SET ON THREE-WIRE SYSTEM

It is necessary to short-circuit the armatures as just described, to determine the direction of rotation, since the set would not start if the directions of rotation of the two machines were opposed; G_1 would tend to revolve one way, whereas G_2 would tend to revolve in the other. Owing to the fact that the armatures would not begin to revolve the current through the starting resistance would be of a value to cause serious heating. To make sure of the effectiveness of the short-circuit, the brushes of the short-circuited machine may be removed. It will then be impossible for any current to flow through the armature, as might be the case if the short-circuiting connection had considerable resistance as compared with the resistance of the armature.

When the balancer set consists of compound-wound machines, the connections are those shown in Fig. 2. To test for direction of rotation, the armatures are short-circuited in turn, as described for shunt machines, and the directions of rotation noted. If opposed, they are made the same by reversing the connections of one of the field circuits, as in the case of shunt machines. The next point to be determined is the direction of the excitation due to the series field. It was shown in a previous lesson that the connections must be such as to make the machines differentially compounded when they are operating as motors. It follows that the direction of rotation due to the shunt field alone would be opposite to that due to the series field alone. Consequently, if we observe the directions of rotation when the fields are used separately, we can tell whether the direction of the excitation is as it should be. To do this, we proceed as follows: Suppose, for example, that we are testing machine G_1. We would first open the shunt-field circuit by disconnecting the field wire at *m* and then short-circuit the armature of G_2 by connecting a wire from *d* to *e*. The machine G_1 would now operate as a series motor and it is therefore important to note that the starting switch must not be advanced past the first contact. If more of the starting resistance were cut out, the motor might race badly, and if it were all to be cut out the motor would "run away" since it would be operating as a series machine with load, and with double normal voltage applied.

The direction of rotation should now be the reverse of that observed during the first test. If it is the same, the connections of the series field H_1 should be reversed; that is, the end that connects to *b* should be transferred to *c*, and vice versa. The test must be made on both fields separately since at no load the effect of the shunt field is much greater than that of the series one, and consequently the direction of rotation observed when both fields are operative is that due to the shunt-field excitation.

Having tested machine G_1 and corrected the field connections if necessary, the same procedure is followed with machine G_2. That is, its shunt field is open-circuited and the armature of G_1 short-circuited. The direction of rotation upon trial should then be the same as when G_1 was tested on its series field alone; that is, it should be the reverse of that observed when the first test was made to check the relative rotation of G_1 and G_2. After it has been established that the connections are correct, the set is ready to be put into service.

If the machines are considerably overcompounded, the rush of current at the instant they are started will cause the series-field excitation to greatly reduce that of the shunt field, and consequently the set will speed up very markedly during starting, since the machines are starting on a weakened field. If this action proves to be objectionable, it can be obviated by short-circuiting the series fields while the machines are being started. This can readily be accomplished by connecting them to a double-pole switch, as shown in Fig. 3, or two single-pole switches could be used. Before starting the set, the switch should be closed, thus short-circuiting the series fields. Then, after the machines have been started and are running at normal speed, the switch is opened, thereby allowing the armature current to flow through the series-field windings. Since the current is small when the machines are once running, there will be little effect on the speed. The short-circuiting switch should be opened and the switch S_N closed, so that the machines shall be running under operating conditions when the voltages across each machine are tested preparatory to putting them into service, as discussed in the preceding lesson.

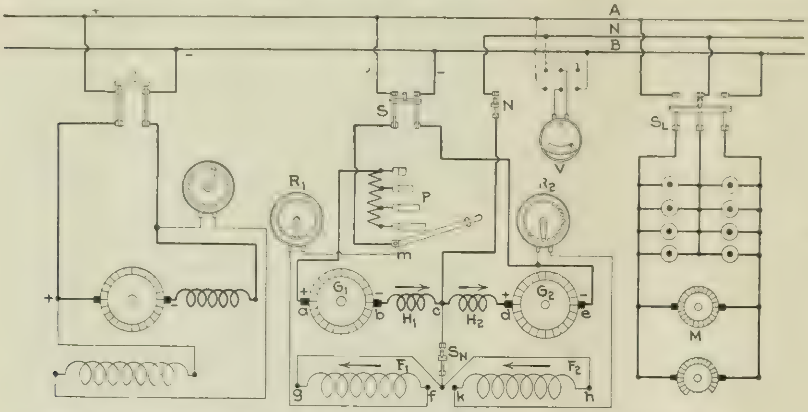


FIG. 2. CONNECTIONS FOR OPERATING A COMPOUND-WOUND BALANCER SET ON A THREE-WIRE SYSTEM

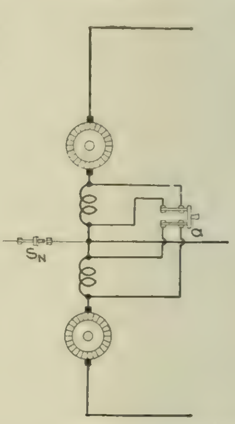


FIG. 3. SHORT-CIRCUITING SWITCH ON SERIES FIELDS

In the preceding problem we have given a 110- to 220-volt three-wire system as in Fig. 4. The loads L_1 and L_2 are composed of lamps and take 120 amperes and 180 amperes respectively. The load *M* consists of motors taking a current of 230 amperes. It is required to find the value and direction of the currents I, I_A, I_B, I_N, I_1 and I_2 in the various parts of the circuit, if the machines G_1 and G_2 take 10 amperes. The total load supplied from the 220-volt source is the sum of all the loads upon it. The load L_1 is equal to 120 amperes × 110 volts = 13,200 watts, L_2 is equal to 180 amperes × 110 volts = 19,800 watts, *M* is equal to 230 amperes × 220 volts = 50,600 watts and the load due to G_1 and G_2 is 10 amperes × 220 volts = 2200 watts. The total load is therefore 13,200 + 19,800 + 50,600 + 2200 = 85,800 watts, and this divided by the supply voltage, namely, 220 volts, gives the line current; that is, $I = \frac{85{,}800}{220} = 390$ amperes. The current I_A is the sum of the load currents of L_1 and *M*, or $I_A = 120 + 230 = 350$ amperes. Similarly, I_B is the sum of the load currents of L_2 and *M*, or $I_B = 180 + 230 = 410$ amperes. The current in the neutral is their difference, or $I_N = 410 - 350 = 60$ amperes. The directions of these various currents is that of the arrows in the figure. Since $I = 390$ amperes and I_A is only 350 amperes, we have $I_1 = 390 - 350 = 40$ amperes, which flows through G_1 from plus to minus; that is, G_1 runs as a motor. On the other hand, $I_2 = I_B - I = 410 - 390 = 20$ amperes, and since I_B is larger than *I*, the current must flow through G_2; that is, G_2 operates as a generator.

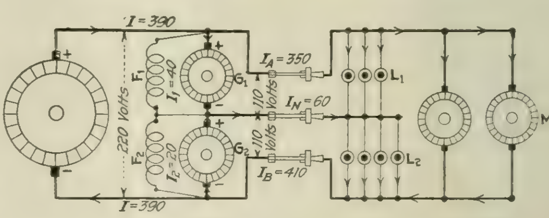


FIG. 4. THREE-WIRE. 110- TO 220-VOLT SYSTEM

It was also required to find the size of machines necessary to use in the balancer set if the total lamp load on each side amounted to 200 amperes and the system was liable to be completely unbalanced at times. When completely unbalanced, G_1 and G_2 would have to take care of the load on one side; namely, 200 amperes. Half of this would pass through each machine. Disregarding the losses in the machines, they would each have to be of 100 ampere capacity at 110 volts, or 100 × 110 = 11,000 watts; that is, 11 kw. It would therefore be safe to install 10-kw. generators, as these would readily stand the overload for such periods as it might last.

A 220-volt generator is to be used in connection with a 110- to 220-volt three-wire system. Its current rating is 455 amperes. How many 40-watt lamps can be supplied without overloading the generator? If a 220-volt motor load takes 60 hp., how many lamps can the generator supply in addition to the motor load? What size of wire should be used for the neutral in the latter case?

Refrigerating Plant Data

Several tables, including those on properties of saturated and superheated ammonia, brine solutions, their freezing temperatures and specific heat, are given, also some practical rules for piping and other information needed by the operator of the refrigerating plant.

USUALLY, the engineer of the common-sized ice and refrigerating plant using ammonia does not take the trouble to provide himself with a refrigerating engineer's handbook. The following data are here arranged for the use of such men, although they are by no means meant to take the place of a handbook or textbook or combination of both; the aim is to give him some of the chief figures and values for which he has use in those problems which from time to time vex him.

SOME PROPERTIES OF AMMONIA

Commercial Ammonia is a solution of ammonia gas in water. The usual strength is 26 deg. Baumé, containing about 38.5 per cent. of anhydrous ammonia.

Boiling Point—At atmospheric pressure commercial ammonia boils at —29 deg. F.

Heat of Vaporization of Ammonia—At atmospheric pressure, 593 B.t.u.

Unit of Refrigerating Capacity—200 B.t.u. per min.; 12,000 B.t.u. per hour; 288,000 B.t.u. per ton of ice melted. The refrigerating capacity of a compressor or absorption machine is more than the actual ice-making capacity by 50 per cent. or more, depending upon the temperature of the water and other less important factors.

TABLE I. PROPERTIES OF SATURATED AMMONIA

(From tables of Goodenough and Mosher)

Temp., Deg. F.	Pressure, Lb. per Sq. In. Abs.	Specific Volume Liquid, Cu.Ft. per Lb.	Specific Volume Saturated Vapor, Cu.Ft. per Lb.	Heat Content Liquid	Heat Content Saturated Vapor	Heat of Vaporization, B.t.u.
—40	10.12	0.0234	25.45	—75.3	526.6	601.9
—35	11.74	0.0235	22.14	—70.2	528.2	598.3
—30	13.56	0.0236	19.35	—65.0	529.8	594.7
—25	15.61	0.0238	16.95	—59.8	531.3	591.1
—20	17.91	0.0239	14.89	—54.6	532.8	587.4
—15	20.46	0.0240	13.15	—49.4	534.3	583.6
—10	23.30	0.0241	11.63	—44.2	535.7	579.9
— 5	26.46	0.0242	10.32	—38.9	537.1	576.1
0	29.95	0.0244	9.19	—33.7	538.5	572.2
5	33.79	0.0245	8.20	—28.4	539.9	568.3
10	38.02	0.0246	7.34	—23.2	541.2	564.4
15	42.67	0.0248	6.583	—17.9	542.5	560.4
20	47.75	0.0249	5.920	—12.6	543.7	556.3
25	53.30	0.0250	5.336	— 7.3	545.0	552.2
30	59.39	0.0252	4.820	— 1.9	546.2	548.1
35	65.91	0.0253	4.364	+ 3.5	547.4	543.9
40	73.03	0.0255	3.959	8.9	548.5	539.7
45	80.75	0.0256	3.599	14.3	549.7	535.3
50	89.0	0.0258	3.278	19.8	550.8	531.0
55	98.0	0.0259	2.992	25.3	551.9	526.5
60	107.7	0.0261	2.734	30.9	552.9	522.0
65	118.0	0.0263	2.503	36.5	554.0	517.0
70	129.0	0.0264	2.296	42.1	555.0	512.8
75	141.0	0.0266	2.109	47.8	556.0	508.1
80	153.9	0.0268	1.904	53.6	557.0	503.4
85	167.4	0.0270	1.788	59.4	557.9	498.5
90	181.8	0.0271	1.650	65.3	558.9	493.5
95	197.0	0.0273	1.524	71.3	559.8	488.5
100	213.0	0.0275	1.408	77.3	560.7	483.4
110	249.6	0.0280	1.305	89.6	562.5	472.9
115	269.2	0.0282	1.122	95.9	563.3	467.4
122	300.0	1.007	0.993	105.3	564.6	459.3

TABLE II PROPERTIES OF SUPERHEATED AMMONIA

(From tables of Goodenough and Mosher)

Pressure, Lb. per Sq.In. Abs.	Temp of Saturated Vapor, Deg. F.		Superheat, Deg. F. 20	40	60	80	100	150	200
20	—15.9	U	14.2	14.9	15.6	16.3	16.9	18.6	20.2
		H	545.2	556.1	566.7	577.1	587.4	612.7	638.0
40	12.2	V	7.40	7.76	8.12	8.46	8.80	9.64	10.46
		H	553.9	565.5	576.8	587.7	598.3	624.6	650.6
50	30.5	V	5.04	5.30	5.54	5.77	6.01	6.57	7.12
		H	559.1	571.2	582.9	594.2	605.2	632.1	658.6
80	44.5	V	3.85	4.04	4.22	4.40	4.57	5.00	5.42
		H	562.8	574.3	587.4	599.0	610.3	637.7	664.6
100	56.0	V	3.10	3.26	3.41	3.56	3.70	4.05	4.38
		H	565.7	578.6	590.9	602.8	614.3	642.2	669.4
120	65.8	V	2.61	2.74	2.87	2.99	3.11	3.40	368.8
		H	568.2	581.4	593.9	605.9	617.6	646.0	673.4
140	74.5	U	2.25	2.37	2.48	2.58	2.69	2.94	3.17
		H	570.2	583.6	596.4	608.7	620.6	649.3	676.9
160	82.3	U	1.98	2.08	2.18	2.27	2.36	2.58	2.79
		H	572.0	589.7	598.6	611.1	623.2	652.1	680.1
180	89.4	U	1.77	1.86	1.94	2.03	2.11	2.31	2.49
		H	573.6	587.5	600.6	613.2	625.4	654.7	682.8
200	95.9	V	1.59	1.67	1.75	1.83	1.90	2.08	2.25
		H	575.0	589.1	602.4	615.2	627.5	657.0	685.4
250	110.1	V	1.28	1.35	1.41	1.47	1.53	1.68	1.81
		H	578.0	592.4	606.1	619.3	631.9	661.9	690.8
300	122.4	V	1.07	1.13	1.18	1.23	1.28	1.41	1.52
		H	580.5	595.3	609.3	622.7	635.5	666.1	695.4

Volume of Ammonia Gas To Be Handled by Compressor (F. L. Fairbanks in Marks' Handbook)—The volume of dry saturated gas (cu.ft. per min.) that must be handled by the compressor to produce 1 ton of refrigeration per day of 24 hours is $V = \frac{200V''}{(r - i')}$ where V'' = cu.ft. per lb. at evaporating pressure, r = latent heat at evaporating temperature and pressure, and i' = heat of the liquid between the limiting pressures:

Example: Head pressure, 199 lb. abs.; back pressure, 29.95 lb. abs. Then $r = 572.2$ B.t.u. and i' 106.6 B.t.u. Also $V'' = 9.19$ cu.ft. per lb. The weight of ammonia per minute $= \frac{200}{(572.2 - 106.6)} = 0.4295$ lb., and cu.ft. per min. $= 0.4295 \times 9.19 = 3.95$. Assuming the volumetric efficiency of the compressor equals 80 per cent., the actual piston displacement $= \frac{3.95}{0.80} = 4.93$ cu.ft. per ton of daily capacity.

Volumetric Efficiency is the ratio of the actual weight of vapor handled by the compressor to the weight calculated from the displacement of the compressor with gas entering at its evaporating pressure; it varies from 60 to 85 per cent. Compressor builders will guarantee 80 to 85 per cent. in machines of 50 tons and over.

Weight of Ammonia Required by Compression System—To estimate the total quantity of anhydrous ammonia required, allow that the condenser space is filled with ammonia vapor at 165 lb. pressure; that the entire volume of the cooler coils is filled with vapor at 20 lb. pressure; for every cubic foot of liquid receiver capacity allow 25 lb. of liquid ammonia.

Practical Rules for Direct-Expansion Piping (F. L. Fairbanks)—One lineal foot of 2-in. pipe to 10 cu.ft. of space in rooms maintained between 32 deg. and 10 deg. F.; one lineal foot to 40 cu.ft. of space in rooms kept between 32 deg. and 50 deg.; one lineal foot to 60 cu.ft. space in rooms kept at 50 deg. F. or above. These values are liberal. One ton refrigerating capacity is a liberal allowance for every 4500 cu.ft. of cold-storage capacity held at 32 deg. F. For every ton of refrigeration allow 260 to 300 ft. of 1¼-in. pipe. Luhr suggests 600 lin.ft. of 2-in. pipe per ton refrigeration for direct-expansion systems, and 750 ft. for brine systems. For storage rooms he allows one foot of 2-in. pipe per 25 cu.ft. of space; for freezing rooms, one foot of 2-in. pipe per 7 cu.ft. space; for fish freezing rooms, one foot of 2-in. pipe per 2 cu.ft. of space.

TABLE III FREEZING TEMPERATURES OF BRINE AT VARIOUS SOLUTION STRENGTHS

Calcium Chloride			Sodium Chloride			
Specific Gravity	Deg Baumé at 64 Deg F	Approx Weight of Salt Required, Lb per Gal	Specific Gravity	Deg Baumé at 64 Deg. F.	Approx Weight of Salt Required, Lb per Gal	Freezing Point, Deg F
1.035	5.0	1.00	1.022	3.0	0.21	28
1.062	8.6	1.5	1.044	6.0	0.52	24
1.085	11.4	1.75	1.067	9.0	0.80	20
1.113	14.7	2.00	1.091	12.0	1.1	16
1.122	15.9		1.117	15.2	1.4	12
1.139	17.9		1.142	18.0	1.8	8
1.155	19.7	2.5	1.168	20.9	0.2	4
1.165	20.7	3.25	1.193	23.5	2.8	0
1.174	21.7					—4
1.186	23.0	3.5				—8
1.197	24.1					—12
1.207	25.2	4.0				—16
1.216	26.1	4.25				—20

TABLE IV SPECIFIC HEAT OF BRINE

Sodium Chloride		Calcium Chloride	
Specific Heat, B.t.u.	Specific Gravity	Specific Heat, B.t.u.	Specific Gravity
0.78	1.200	0.98	1.024
0.86	1.100	0.91	1.076
0.94	1.050	0.86	1.121
0.98	1.020	0.83	1.179
....	.....	0.79	1.219
....	.....	0.77	1.240

Brine Velocity—This should be kept below 180 ft. per minute.

Capacity of Compressor, Tons (Luhr)—The formula is for the theoretical capacity; deduct 25 per cent. for the actual capacity:

$$T = \frac{d^2 \times 0.7854 \times S \times 2 \times r \times h \times 1440}{1728 \times 288{,}000}$$

in which

$T =$ Tons refrigeration in 24 hours;
$d =$ Diameter of compressor in inches;
$S =$ Stroke in inches;
$r =$ Revolutions per minute;
$h =$ Refrigerating effect of one cubic foot of refrigerant at refrigerator pressure, completely evaporated from liquid at condenser pressure.
1440 = Minutes in 24 hours.
288,000 B.t.u. equivalent of one ton of refrigeration.

Example: Find the capacity of a double-acting compressor 9½ in. x 16½ in. stroke, 70 r.p.m.; suction pressure, 25 lb. gage; discharge pressure, 165 lb. gage.

TABLE V. AMMONIA CONDENSER DATA

(For clean, unobstructed, free of air and foul gases, 70 deg. F. water, 200 lb. abs. pressure)

Type	Surface per Ton Refrigeration, Sq.Ft.	Heat Transmission per Sq.Ft. per Min. per Ton Refgeration	Pipe per Ton Refrigeration Common Size, In.	Pipe per Ton Refrigeration Lineal Ft.	Water Required per Min.perTon, Gal.
Atmospheric.......	24	8.5	2	45	2 to 3
Flooded atmospheric	6	33	2	11	1½ to 2
Flooded double-pipe	8	25	1¼	22	1½ to 2
Double-pipe	8	25	1¼	22	1½ to 2
Coil	16	12	2 to 1¼	30 to 45	2.5
Tube.............	18	11	1½	55	2 to 3
Submerged	35	5.7	2	65	4 to 7

Solution: The refrigerating effect of one cubic foot of ammonia vapor expanded between the given pressures is 67.1.

$$T = \frac{9\tfrac{1}{2} \times 9\tfrac{1}{2} \times 0.7854 \times 16\tfrac{1}{2} \times 2 \times 70 \times 67.1 \times 1440}{1728 \times 288{,}000}$$

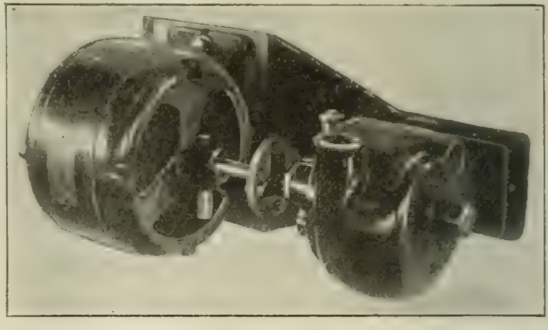
$$= 35.42 \text{ tons in 24 hours.}$$

Actual Horsepower Required per Ton of Refrigeration (Luhr)—The horsepower varies from 1.25 to 2 hp. per ton refrigeration, varying with size and condenser and suction pressures. On the average a 6-ton machine requires 2 hp. per ton, a 25-ton 1.54 hp. per ton, a 50-ton 1.27 hp. per ton, and a 100-ton 1.25 hp. per ton.

A 1000-ton compressor in the Quincy Market plant, Boston, at 750 tons capacity produced a ton refrigeration on 0.9 hp., compound condensing Corliss engine. A 400-ton machine, in the same plant gave a ton capacity for 1.25 horsepower.

"Fulflo" Motor-Driven Pump

The motor-driven lubricant pump shown in the illustration has just been placed on the market by the Fulflo Pump Co., Blanchester, Ohio. This pump is built in ⅜-, ¾-, 1- and 1¼-in. sizes arranged for either floor or wall mounting and is equipped with ⅛-, ⅓-, ¾- and 1-hp. motors respectively. The pump shown in the illustration is the ¾-in. size equipped with a ⅓-hp. motor running 2700 r.p.m. The capacity at this speed is 21 gal. per min. with an 11-ft. head, 20 gal. per min. with a 12½-ft. head, and 11 gal. per min. with a 24-ft. head. The pump, of the centrifugal type, having both intake and outlet at the top, retains enough fluid for priming purposes.



"FULFLO" MOTOR-DRIVEN PUMP

The impellers are of the semi-inclosed type and are supported by a bearing at either end of the impeller shaft, the thrust on the suction side of the impeller being taken care of by a hardened-steel thrust collar on the shaft, which turns against the nose of the bronze bushing supporting the impeller shaft on the suction side of the pump. The main pump bearing also forms the pump gland and is of cast iron. The lubrication of this bearing is taken care of by a sight-feed oiler which feeds into a pocket surrounding the bearing.

The pump is attached to the base by six screws, three of which extend through the motor and pump base and three through the motor base only, the pump base resting on their points. This construction makes it possible, by adjusting these screws, to bring the pump into line with the motor; then the screws are locked in place.

Curing a Chronic Case of Cracked Head

By D. L. Fagnan

ERECTORS of oil and gas engines in their experience become familiar with a wide range of troubles and the remedies employed to overcome them. In the case of at least one company manufacturing such engines, the erecting engineers and troublemen get together at stated intervals, exchange experiences and discuss new and up-to-date methods of erection, trouble chasing, kinks and ideas which they have learned during their absence on important jobs. These meetings tend to keep the men in touch with new developments and bring about distribution of knowledge. Each man contributes his share, and if he is sensible absorbs his share, of the valuable experiences.

One of the most interesting incidents in my own experience as a troubleman and erector was a case of cracked head in a Diesel engine of 225 hp., operating in the power plant of a suburban railroad. There were two engines, of the three-cylinder vertical type, but only one of them was chronically troubled with cracking of the head. Five of these heads broke in a period of three months, and the company wished as heartily as the owner that the cause could be found and the trouble remedied.

In passing through the city in which this plant was located, I dropped in casually and learned of the trouble that had been experienced. However, as my time was limited, I had opportunity for only a brief examination of the plant, during which I detected nothing wrong. Consequently, I had no chance to help them out and so simply reported the matter to the home office on the daily report sheet. Shortly afterward the home office received an urgent message to send two new heads as well as a man to locate the trouble and prescribe a remedy. As I was the nearest man to this locality, I received orders to rush there at once and set things right.

Noting Temperature of Cooling Water

My first move was to get a line on the water-cooling system. I observed the piping layout and the valve system on the manifold and noted the temperatures at the inlet and the outlet from the cylinders. There was only one thermometer on the main inlet to each engine, but a thermometer was provided on each outlet from each cylinder head. With the inlet water having a temperature of 56 deg. F., the temperatures at the outlets were 130 deg., 136 deg. and 145 deg. on cylinders Nos. 1, 2 and 3, respectively. These temperatures were observed with the engine running under normal conditions. Five minutes after shutting down, the outlet temperatures were found to be 96 deg., 105 deg. and 120 deg. respectively. These figures indicated a considerable variation in temperature.

As all of the valves were open wide, something was evidently radically wrong about the manifold or the piping. The first thing that entered my mind was that the burrs had not been removed from the nipples or the piping after cutting with an old-style pipe cutter. It also occurred to me that, in combination with the foregoing trouble, pipe scale or an accumulation of rubbish in the manifold might have caused a restricted opening, thus allowing only a small supply of water to pass into the farthest cylinder. Accordingly, the manifolds of the engine were entirely dismantled, all nipples reamed out, and all ells and tees cleaned thoroughly and reassembled.

The water plugs on the head and water jacket were removed, and all accumulation of sludge removed with a hose. Then a 10 per cent. solution of muriatic acid was run in. A system of piping was rigged up to catch the solution after it had lain in each cylinder head for a few hours, since the acid solution may be used repeatedly by strengthening it occasionally with acid. It is very effective in removing scale from intricate passages and eats away the usual scale very quickly, causing effervescence while it is acting; but the cylinder head must be washed out clean immediately after the acid solution is removed.

Proposed Water-Softening Equipment

We next inspected the water supply and found that it came from an artesian well. The tank containing the cooling water held about 2000 gal., and the water was cooled by means of a home-made cooling tower, which was very effective, as the weather was quite cold. My proposal was to soften the water with a drum of aqua ammonia that was in the plant. This ammonia was worked into the cooling-water line gradually, but as the plan was only a makeshift, I proposed that they consult a chemist in regard to softening the water. For it was my opinion that a combination of scale and a scant supply of water due to obstruction had caused local overheating and cracking of the cylinder head at the bridges and the ports.

The engineer was in the habit of allowing the circulating water to flow for five or ten minutes after stopping the engine, and no fault could be found with the method of operating the plant. Everything finally seemed all right, so I watched the outlet temperatures carefully, manipulated the several valves so as to give uniform outlet temperatures, and then fixed these valve settings permanently, since one main water valve served to start and stop the circulation.

On the third day after my arrival, I considered conditions permanently remedied. Six months later I wrote to the plant to find out if any new difficulty had arisen and they replied that no further trouble had occurred. Meanwhile, they had installed a water-softening system of home-made design that had proved successful. It was practically a distilling system receiving heat from the hot exhaust gases.

My experience indicates that the cracking of cylinder heads occurs after the engine is shut down and is due to the contraction of the cooling metal after the water supply has been stopped and not to expansion caused by overheating.

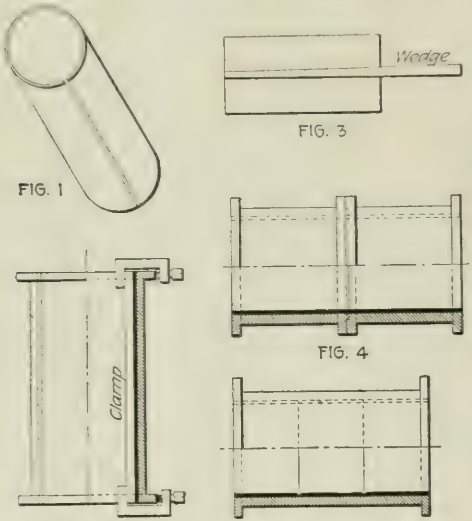
Some engineers claim that 125 deg. F. is the highest allowable outlet temperature for the jacket water; others say 110 deg. is correct, and still others insist that 160 deg. is not too high. My experience indicates that if the water tends to form scale in the heads and jackets, 90 deg. is a good temperature. If the water is free from scale, go higher, even to 160 deg., as fuel economy is increased thereby. If piston-pin bearings give trouble by overheating, then the outlet temperature should be lowered.

Composition Lined Cylinders

By A. M. STILES

CYLINDERS lined with a noncorrosive metal are necessary in the construction of air pumps and hydraulic valves. They are also extensively used on the water ends of piston pumps. These liners can be made of standard tubing where the diameter does not exceed 16 in. In the design of air pumps for condenser service, where the pump is driven by a projecting bracket of the main pump (which is standard practice in water-works construction), or in hydraulic valves, where the stroke or lift is dependent upon the size of the valve, the volume of the cylinder will depend upon its diameter, which then becomes an exact dimension not obtainable in the standard sizes of tubing.

Sheet stock can be advantageously used for cylinders of this type, the diameters being limited only by the length of the sheet obtainable. The cylinder is bored to the required size, with an allowance for the thickness of liner stock, which should be at least $\frac{1}{4}$ in. thick for cylinders over 20 in. in diameter and in no case less than $\frac{3}{16}$ in. The sheet is then rolled, as shown by Fig. 1, in the direction of its length to a diameter that will permit it to fit freely but snugly into the cylinder. The ends of the sheet must not touch after rolling, but should be open from $\frac{1}{8}$ to $\frac{5}{8}$ in. for cylinders from 18 to 40 in. in diameter. If, after rolling, the edges touch or are not parallel, they can be planed or milled.



FIGS. 1 TO 5. VARIOUS TYPES OF COMPOSITION LINERS

The liner is then dropped into the cylinder and stayed by clamps, as shown in Fig. 2, from three to six equidistantly spaced clamps being used, the number depending on the size of the cylinder. The entire inside surface is then peened to bring the metal in close contact with the cylinder wall and to close the space between the ends of the liner. The peening operation is started opposite the slot and worked from the center to the ends, the clamps being removed to new positions to permit peening under them. When the edges of the sheet touch, the clamps may be removed altogether. The final blows of the hammer cold-weld this seam, making it tight and nearly invisible. A finish cut is necessary, and, if the peening has been evenly and carefully done, no more than $\frac{1}{32}$ in. of metal need be removed.

Another method of using the sheet-stock liner is shown by Fig. 3. After the liner is rolled to the correct diameter, the edges are planed taper to receive a wedge of the same stock. This wedge is about 1$\frac{1}{4}$ in. wide and tapered about $\frac{1}{16}$ in. per foot of length. After the liner is placed in the cylinder, the wedge is driven home, forcing the liner against the cylinder wall, after which it is peened all over as in the first case. This method involves more machine- but less floor-work than with the single piece. Two seams are not an objection as they are tight and the clamps are dispensed with.

The use of sheet stock insures contact between the inner cylinder wall and the outer surface of the tube, for the peening operation, after the edges of the liner touch, increases the diameter to a much greater tolerance than could possibly be allowed for a press fit where the liner is cast in tube form and turned up. For instance, if 0.001 in. excess diameter were allowed for drive in a cylinder 25 in. in diameter by 40 in. stroke the liner would probably buckle in driving it home, owing to the friction set up by its length, and it is usual to allow nothing at all for drive, but to turn the liner to the exact bore of the cylinder; there is, therefore, no pressure exerted by the liner at right angles to the cylinder axis irrespective of the pressure required to drive it home, a condition that is conducive to leaks and corrosion of cylinders walls. Sheet stock has the further advantage of high tenacity and malleability.

Owing to the scarcity of both tubes and sheet stock during the war, cast liners were often used with good results, although perfect castings are difficult to make even when cast $\frac{1}{2}$ in. thick, because of the uneven proportion between the thickness, diameter, and length and the excessive shrinkage of composition stock.

Fig. 4 shows the construction of two 36 x 80-in. hydraulic valve cylinders made for the St. Louis Water Department. Both cylinders and liners are cast in two sections to simplify the foundry work. A male and female groove is turned in the cylinder sections to keep them in alignment. The liners were cast in a vertical position and, having a thickness of $\frac{7}{16}$ in. when finished, were forced into the cylinder sections.

Fig. 5 shows the method of lining fifteen 26 x 42-in. cylinders also used for valves; in this case the cylinders were cast in one piece, but the liners were made up in three sections as shown; they were cast $\frac{1}{2}$ in. thick, finished to $\frac{9}{32}$ in., turned to a diameter that would permit them to fit freely into the cylinder and peened all over to insure contact with the cylinder wall. The edges were beveled, as shown, about $\frac{1}{64}$ in. to insure a tight joint next the iron. This bevel was closed by the peening operation, and after the finish cut was taken no joints were visible. These sections were also cast vertical, and their comparatively small size permitted rapid production both in the foundry and shop without the use of special and heavy apparatus necessary for the single tube. There was also an improvement in the quality of the castings.

EDITORIALS

The Mobile Boiler Explosion

THE Mobile explosion described on page 432 *et seq.* is one of the most notable of recent years. Although but two boilers apparently exploded and only four were thrown from their settings, the toll in lives and property of the explosion and the fires which followed was greater than that which has resulted from explosions in which more boilers were involved.

Out of the tangled mass of drums, tubes and headers yielded up by the débris it is possible to deduce the fact that two of the boilers were ruptured in such a way that either might have been the source of the trouble. A Heine failed by breaking off the rear drum head and the back water-leg through the upper line of tube- and hand-holes, and splitting the drum longitudinally through the solid sheet. A Stirling failed by blowing out the closed end of its mud drum by one of those circular fractures around the crown of the flange about which there has been so much discussion and which have shared with the lap-joint crack the responsibility for a number of the recent serious accidents. The Heine had been in operation about fifteen and the Stirling about twenty-two years.

Which rupture occurred first? Which was responsible for the wreck of the other? These are questions that are likely never to be answered positively, for the clearing up was promptly commenced, and the location to which some of the boilers and fragments were projected cannot be determined.

If the explosion had been general, the finding of such a positive proof of rupture as the disk from the Stirling drum head would seem to fix the initial fracture. The fact that only one Heine exploded, and this with considerable violence, gives plausibility to the claim that it may have been the first to explode and that the shock caused the blowing out of the weakened end of the Stirling drum. The direction taken by the Stirling supports this view, although No. 6 might have landed where shown, by exploding against No. 5 and the latter then have been projected to its location by the subsequent explosion of the Heine. The two closed heads of the Stirling drum were in line with each other in the partition wall. The head from No. 5, which should have received the impact of that from No. 6 if the latter blew out while the drum was still in place, was found uninjured, but we do not know where. It would have been shielded from direct impact by the division wall. The location of the disk from No. 6 would be enlightening if it could be determined.

The water in a boiler at one hundred and sixty pounds pressure has a temperature of over three hundred and seventy degrees. When the pressure is reduced to that of the atmosphere, about fifteen per cent. of the water flashes into steam with an instantaneous swelling of the contents to the full capacity of the containing vessel, with a water-hammer result similar to that which would be produced by filling the boiler completely with water, putting a loosely fitting plug into the steam nozzle and dropping the hammer of a pile driver on it. The explosion of seven Heine boilers at St. Louis in 1904 was evidently caused in this way. The breaking of a steam main released the pressure suddenly, and the seven boilers were scattered over a wide area. The destruction of one of the boilers was much more complete than that of the rest. It was rent and torn, not through the seams and the obviously weakest points, but through the solid sheet in the back end of the main drum.

The exploded Heine boiler in this case has evidently been subjected to some such violent action. The drum is torn through the solid sheet and the magnitude of the forces involved is evidenced by the enlargement of many of the stay-bolt and other holes.

The question of the possible failure of the Heine boiler from excessive pressure is raised. The recording pressure gage upon the system shows a pressure of a little over one hundred and sixty pounds at the time of the explosion. There was one or more automatic return valves in the steam line, but information as to whether the arrangement was such that its sticking would allow an excessive pressure to build up in one or more of the boilers is not at hand.

Whether the Stirling went first or not, it had in its weakened head the possibility of failure at any time. This is no discredit to the boiler which had twenty-two years of service to its credit, but to the setting of the head in such a position that it was practically inaccessible for inspection.

We shall seek further information and present it as obtained. In the meantime our readers may have pertinent knowledge or ideas, which are solicited for our correspondence columns.

Reading a Watt-Hour Meter

TOO often is the important matter of reading a wattmeter trusted to an unskilled or careless reader, who reports a certain amount of energy used, and the customer is billed or the department charged accordingly. The customer pays his bill without protest with the result that neither the electric company nor the user is any the wiser. So it behooves the efficient operating engineer who has electrically operated machinery, to read the meter and satisfy himself that he is getting all the energy for which he pays or that he is not basing operating costs on a low cost of energy due to a wrong electric bill.

That this subject is of vital importance is shown by the fact that such an error in reading was the basis of an extensive lawsuit involving thousands of dollars. An electric company supplied energy to a consumer only a few miles from New York City, and made an incorrect charge. Each month they forgot to multiply the reading by a constant of ten, resulting in a billing to the consumer of only one-tenth of his correct bill. The consumer used the electric-energy charge in computing the cost of his product. When, after some time, the electric company discovered its mistake and billed the customer for the descrepancy, payment was refused, which resulted in a lawsuit and a dissatisfied customer.

The article on "How to Correctly Read a Watt-Hour Meter" in this issue, is not at all technical and treats the subject in such detail that this seemingly complicated matter is rendered easy to master. It deals with the different forms of watt-hour meter dials used by various manufacturers, telling what the various markings mean, and gives simple instructions by which the layman can readily tell how much electric energy he has used and how much his bill will be.

United States Nitrate Plant Number Two

BEGINNING in this issue we publish the first of several articles descriptive of the new steam station of United States Nitrate Plant Number Two at Muscle Shoals, Alabama. This is the steam station for the large nitrate plant of the United States Government and is truly one of the most interesting power stations ever built. As pointed out in the article, the conditions on which the engineers based their design are so close an approach to the ideal that one must have this thought in mind when considering the performance results expected by all who know the plant well.

The plant's history is illuminating. In the fall of 1917 the United States War Department was faced with a serious problem: The supply of nitrogen available for the manufacture of high explosives was found to be a small fraction of the amount required to meet the munitions program for the rapidly increasing army.

In modern warfare it is the rate at which ammunition is used that wins battles and wars. In the war on the western front about two tons of ammunition were used for each soldier killed, captured or seriously wounded. Increasing the rate at which ammunition was sent to the front would perhaps have saved one soldier for each extra two tons of ammunition. It was then a question of speed of munitions manufacture against men. Upon the Production Division of the Ordnance Department was placed the serious and difficult responsibility of obtaining, without fail, an enormous quantity of high explosives to meet a tremendous military program.

Every military explosive is a nitrogen compound made from nitric acid or ammonia, or both. Military explosives are of two classes—propellants for hurling projectiles and high explosives for bursting the shells or bombs. The high explosives used are TNT (trinitro-toluol) made from toluol and nitric acid; picric acid, made from benzol and nitric acid; and ammonium nitrate, made from ammonia and nitric acid. It was the shortage of these high explosives that threatened to hold up the munitions program.

Toluol and benzol were obtainable only in small quantities as byproducts of the coking of coal. The entire production could furnish only a small fraction of the requirements. The cost of TNT and picric acid was about two and one-half times the cost of ammonium nitrate from ordinary sources; therefore the Ordnance Department preferred to increase the supply of ammonium nitrate to mix with the TNT.

The only existing sources of ammonia, however, were the byproduct coke ovens and gas works. The capacity of ovens had already been doubled since the beginning of the war. The cost of construction had risen to about two and one-half times normal. To furnish the amount of ammonia needed, another doubling of capacity would have been required, so that the final outlay would probably have been several hundred million dollars. The period required for the construction would undoubtedly have postponed the entire military program.

To get the other material required—namely, nitrate of soda—would have placed additional heavy demands upon the supply of ships, already seriously reduced by the submarine campaign. The conversion of the nitrate to nitric acid would have required concentrated sulphuric acid, ton for ton, and the sulphuric-acid supply was far behind the requirements. All these large-scale operations, the building of ovens, the coking of great additional tonnages of coal, the hauling of the ammonia liquors, the nitrate and the sulphuric acid would have placed a stupendous burden upon the already overloaded railroads.

In this emergency, in the fall of 1917, the American Cyanamid Company, on invitation, laid before the Ordnance Department a plan for the manufacture of ammonium nitrate from the common materials, limestone, coal, coke and air. One or more plants, each complete in itself, could be built within twelve months, to supply the entire quantity of ammonium nitrate desired, and at less than one-half the prevailing cost.

The practicability of producing ammonia and nitric acid from the air for the manufacture of explosives had indeed already been a subject of investigation by the Nitrate Supply Committee of the War Department. A plant using a modified Haber process was under contract to be erected at Muscle Shoals, Alabama, with a capacity equal to 22,000 tons of ammonium nitrate per annum. This plant, known officially as United States Nitrate Plant No. 1, was being built under a Congressional appropriation of twenty million dollars made about a year and a half previously. Several other new processes also were to be tested here. Inasmuch, however, as none of the processes to be used at Plant No. 1 had ever operated commercially, and would not therefore be fully depended upon, the Ordnance Department, with its tremendous responsibility, was unwilling to consider the extension of any of these processes as a solution of its problem.

Fortunately, the dependability of every step in the cyanamid processes had already been proved by actual commercial operations over a period of years.

At the request of the War Department, the American Cyanamid Company formed a subsidiary corporation, known as the Air Nitrates Corporation, to act as the agent of the United States Government for the construction and operation, under the cyanamid processes, of a plant at Muscle Shoals, Alabama, to produce 110,000 tons of ammonium nitrate per annum. This plant is known as United States Nitrate Plant No. 2. Construction was determined upon November 16, 1917. The first carload of material was delivered December 20, and the first ground was broken February 16, 1918. More than thirty thousand men were employed on construction at its peak.

The plant began operating October 23, 1918, eight months after ground was broken. The site occupies 2200 acres, including a permanent village built to accommodate twelve thousand people. The additional plants, each with one-half the capacity of the Muscle Shoals plant, were also contracted for in July, 1918, to be built and operated for the Government by the Air Nitrates Corporation. Work on these plants was abandoned after the signing of the armistice. In a little over one year of actual construction work, therefore, the country would have acquired a cyanamid-nitrates production equal to the total production of ammonia from all sources in this country at the time construction was decided upon.

While the station embodies the most modern practice in every respect, the reader should have before him the thought that the ideal conditions encountered have influenced design accordingly. Economizers were not installed although provision has been made for their convenient installation, should conditions warrant them. The house turbines are operated noncondensing, and practically all auxiliaries and the service pumping station are electrically driven, realizing the high efficiency of this form of drive.

Original plans called for a plant of 90,000 kilowatts—one 60,000-kilowatt and one 30,000-kilowatt turbine of the reaction type. The former is installed and the latter may be put in at some future date. The large unit is of the cross-compound triple-cylinder, multiple-expansion parallel-flow type, 60-cycle, three-phase 12,000 volts, 60,000 kilowatts, at eighty-five per cent. power factor.

The coal factor at this plant will likely be one of the lowest had anywhere; in fact, some of those closely associated with the station believe that it will be down near one pound.

The Appalachian Power System

THE South owes much of its development in recent years to cheap power. Fortunately, it abounds in water power, and cheap power is one of the vital natural assets in the industrial growth of a country or section of country. One need but call to mind Lowell, Holyoke, Augusta, Cohoes and Niagara to convince oneself how vital is cheap power.

Of the recent water-power developments in the South, those of the Appalachian Power Company are interesting. This company owns several water-power sites, two of which have been developed. Deserving of special attention is the system of interconnection which it is effecting in Virginia to furnish power for the coal mines, utilities and industrial plants in the southwestern part of Virginia and the eastern part of West Virginia. In addition to the hydro-electric plants which were installed in 1911 and 1912, there has just been completed a modern steam-turbine station of twenty thousand-kilowatt capacity at Glen Lyn.

The interconnection between this company and the Norfolk & Western Railway and the Roanoke Electric Railway and Electric Company greatly facilitated the operating problems of last year, when efforts were being put forth to keep the mines operating at full capacity. The United States Navy derives practically all its coal from this section, which produces the finest steam coal in the country. It was especially valuable during the war for the use of the Navy, because the smoke produced was much less than with any other coal and the visibility of boats using it was therefore much less.

During the period of great industrial activity brought about by the war, there was in this country a serious shortage of power, and this condition will again prevail unless steps are taken to start new developments without delay. The failure of the last Congress to pass the water-power bill and to appropriate the money asked for by Secretary Lane for the purpose of defraying the expenses of a survey of the power situation on the Atlantic Coast is greatly to be deplored, and strong efforts should be made by those interested to educate the next Congress in order to have this legislation passed.

Although the hydro-electric plants of the Appalachian Power Company were built several years ago, the system as a whole represents some unusual features. The units are the most efficient that have ever been tested and reached the high figure of 93.9 per cent. The new steam station is improved in every respect, and high efficiencies are predicted for it. As stated in the article, simplicity was the keynote of the design.

The chief data covering both the hydro-electric and the steam stations, arranged for convenient filing and reference, are given in the article.

Operation at Holtwood

THERE begins in this issue the first of several articles dealing with operation in the large hydro-electric station at Holtwood on the Susquehanna River. The articles treat of the important features of operation, including training of the power-plant crews, governor regulations, governor and general hydraulic maintenance, inspection methods, lubrication of submerged pins in the governor-operating mechanism, maintaining high station efficiency, care of the main transformers, handling ice situation, report and record forms at Holtwood.

These articles should be well received—first, because of the deep, broad interest in water power, so much of which is still undeveloped on this continent, and second, because they deal with operation as practiced in one of the leading stations in this country. There is a third reason why they should be widely read; namely, articles dealing with hydro-electric operation are perhaps among the scarcest things in engineering literature. Search the bibliographies and one will be surprised at the paucity of such engineering literature. It should not be so. Ours is a country that abounds in water power. The war and the woeful shortage of power and coal which it precipitated brought home to the country as nothing else could, the need of turning to commercial use the hundreds of thousands of horsepower of water energy as yet unharnessed. If the developments are to operate most successfully, there must be available to the engineers who operate them and to the young men who later will operate and design them literature which they can use as a tool.

To get it a technical paper must send its editors to the plant. This is and has been the condition. It should not be so. There are volumes of valuable technical data in the files of consulting hydro-electric engineers and others; the chief operators and their assistants, isolated in the mountains as they usually are, could, if they would, make worth-while contributions to their technical literature. The builders of hydro-electric plant equipment, particularly builders of the hydraulic machinery, have shut themselves in too closely for their own and the profession's good. The time is propitious for a widening out of hydro-electric literature. It is hoped the present articles will overcome the inertia and that the opinions and practices of men in this growing field will find wider expression.

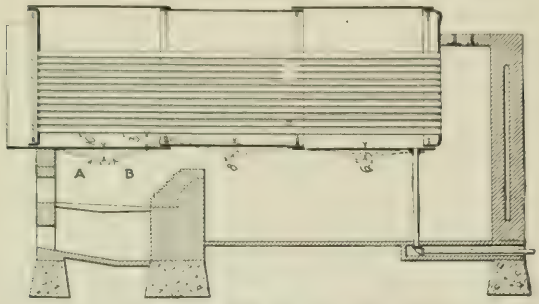
The average steam plant is of the most simple design, and many of the devices found in the larger modern stations are not included in their equipment. The object of the supplement to this issue is to show the application of some of the apparatus and specialties that go to make up a modern steam-power plant. No attempt has been made to incorporate all the apparatus that is to be obtained, but the most essential equipment.

· Correspondence ·

Low Water Ruins Boiler

At about 5 a.m., Jan. 2, a boiler in a plant at the edge of the business district of Salt Lake City, Utah, exploded, but little damage was done to the setting or connections.

The night watchman had been required to get the boilers ready for the fireman. Although the engineer had taken pains to instruct the watchman as to the duties and had pointed out the necessity of being careful regarding the water, the latter in some way made a serious mistake in assuming that the boiler was full of water, so he opened the blowoff valve, and when the water level appeared to be at two gages, he closed the valve and started a fire in the furnace.



DISTORTED PLATES DUE TO OVERHEATING UNDER PRESSURE

The setting housed two 72-in. return-tubular boilers. The fires had been banked the evening before, and about 60 lb. pressure was on the boiler. Some time after the fires had been started, there was a loud report and fire and steam began blowing from the furnace of one boiler. The engineer was called, but by the time he arrived the pressure had been relieved and all was quiet.

It is evident that the watchman had not ascertained the true level of the water, which was low. He blew out nearly, if not all, that was in the boiler through the blowoff line and the steam from the other boiler, not being prevented by a nonreturn valve, produced an excess pressure on the rapidly heating plates until the bagging drew the plates so thin they could not withstand the pressure, and a rupture followed in the first sheet directly over the fire. The second and third sheets were also badly bagged.

The first sheet appeared to be down about 10 in., the second 8 in. and the third about 6 in., and between the first and second sheets the girth seam was raised about 3 in. The tubes were badly warped and twisted. New plates are to be put on while the boiler remains in place. The dotted line in the illustration gives some idea of the appearance of the bottom of the boiler. The rupture was from *A* to *B*, making a ragged opening 12 in. long and about 1¼ in. at the widest place. The thickness of the plate was less than $\frac{1}{16}$ in. around the hole.

Salt Lake City, Utah. WILLIAM E. PIPER.

Repairing a "Nigger" Cylinder

Following is a description of a repair job to a sawmill "nigger," or log canter. The sawyer had allowed the piston in one of the cylinders to overtravel, resulting in a broken cylinder head and the piston going out far enough to allow the rings to open. When an attempt was made to put the piston back, the rings broke and became wedged between the cylinder and the piston, cracking the cylinder for about two-thirds of its length. There being no spare cylinder, the mill had to shut down.

We sent to the manufacturers for a new cylinder, but could not get delivery for several weeks. The question was how to make repairs. The "nigger" was dismantled and the cylinder sent to be welded, but word came back that the job could not be done. In the meantime the mill foreman had been hunting around town for a substitute cylinder and discovered a section of an old steam-feed cylinder of the right bore, but six feet long, or one foot too long for our purposes, and there was no provision for bolting the valve to the cylinder.

Fig. 1 gives an idea of where the break occurred, and Fig. 2 shows how the new cylinder was shortened and provision made for bolting the control valve to the cylinder. The top did not require a faced surface, and the piping at the left of Fig. 2 shows how the entering steam and the exhaust were taken care of in the top end of the cylinder, the pipes being coupled to the control valve, which was constructed so as to handle both ends of the cylinder.

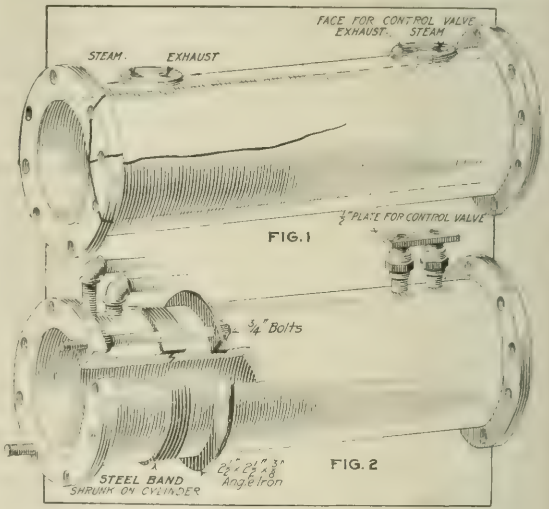

FACE FOR CONTROL VALVE
EXHAUST
STEAM
STEAM
EXHAUST
½" PLATE FOR CONTROL VALVE
FIG. 1
¾" Bolts
STEEL BAND SHRUNK ON CYLINDER
2½" × 2½" × ⅜" Angle Iron
FIG. 2

FIG. 1. CRACKED CYLINDER. FIG. 2—HOW NEW CYLINDER WAS SHORTENED AND JOINT REINFORCED

This job took 24 hours and the cylinder has been working for several months without giving any trouble.

Vancouver, B. C., Canada. D. J. H. TAYLOR.

Theories of the Mobile Explosion

Careful investigation of the premises, available parts of the boilers and the verbal evidence of others seem to make it practically certain that in the case of the Mobile boiler explosion the initial rupture occurred in the No. 6 Stirling boiler. The evidence is incontrovertible that the lower head of this boiler was very greatly reduced in thickness through corrosion, that there was not sufficient dish for the diameter and pressure, and that the inevitable breathing action had weakened the material at the point of change in curvature from a dish to a flange, so that a crack had developed around a large proportion of the circumference. The shape and characteristics of the blown-out head substantiate this statement.

At the time of our examination, five or six days after the accident took place, the lower drum out of which the head had been blown could not be located, having evidently been cleaned up with other débris and taken away. It is impossible therefore to say where it finally came to rest. It is quite evident, however, from the appearance of the wreckage that the parts of this boiler had been widely separated, and it is probable that the tubes in violently discharging their contents after the sudden release of pressure through the failure of the head, blew the several upper drums upwardly and, of course, tearing away the steam main. Failure of the steam main suddenly released the pressure on the other boilers which were tied into the same line, which would naturally tend to cause explosive action in the interior of each one of such boilers; and it is quite likely, although not susceptible of absolute proof, that this gunlike action of the tubes of No. 5 Stirling boiler violently separated the several drums of that boiler although without rupturing any of them. None of them showed any such deterioration as the failed head of No. 6.

The reduction in pressure due to the failure of the steam main, which probably tore loose the connections to No. 4 Heine boiler, caused an action in the interior of those boilers similar to that described above in connection with the Stirling boilers. In one of the Heine units this action was sufficiently violent to loosen the whole of the tubes, thereby forcing the two water-legs apart. These water-legs, however, being held strongly together at the top edges by means of the shell, bent sharply, and in the case of the rear one the force was sufficient to tear the water-leg in pieces, pulling out the drum head and also starting a rupture which tore the shell considerably at the forward end.

With but minor exceptions of such a nature that no inherent weakness could be attributed thereto, the metal throughout showed excellent characteristics as to ductility.

The tremendous amount of energy freed is shown by the uniform enlargement of many of the stay-bolt and other holes. The consistency of the design of the details is very marked from the way in which failures of the various parts took place. In the case of a riveted joint there was evidence of failure by combined rivet shear, crushing of metal and tearing of net metal between rivets. In the case of throat stays they broke in the shank, both through and outside of the rivet.

None of the lap-riveted joints, with the exception of the one header which was pulled out, failed, the metal in fact tearing through the roundabout joints, leaving both those and the lap-riveted longitudinal joints intact. The other Heine unit was undamaged so far as internal explosive action is concerned.

From the relative locations alone of the various parts of the several boilers, it is impossible to deduce a conclusion with any certainty as to whether it was the Stirling or the Heine boiler that failed first, but in view of the known weakness of the lower head of the drum of the Stirling boiler and known failures of various types of boilers in recent years from exactly the same phenomena, it is most reasonable and practically beyond peradventure that this is where the initial failure occurred.

The directions in which the drums of the Stirling boilers went are such as would be expected from the failure of the lower drum. The parts of the exploded Heine boiler went in the directions that would be expected from the way in which that boiler exploded, this action being substantially in line with the longitudinal axis of the boiler, there being relatively little side effort. That the force was in this direction was indicated by the position of the unexploded Heine unit, which was more to the front than to the side.

The analogy to the failure of a chain at its weakest link is applicable in this case.

The statement of a negro fireman who claims that he saw the Heine boiler let go first is without weight because it was impossible for him at the point where he was located to see at all clearly any of the boilers, and the Stirling boilers not at all. The interval of time between the two explosions was unquestionably entirely too short to have enabled even a much more intelligent person under such terrifying conditions to have gone through the mental processes necessary to analyze the situation, and any evidence of that sort must unquestionably be regarded as incompetent. E. R. FISH,

Secretary, Heine Boiler Co.

Phoenixville, Penn.

It is our understanding that you expect to publish an account of the unfortunate boiler explosion which occurred on Feb. 21, 1919, at the Mobile Electric Co., Mobile, Ala.

We inclose herewith sketch[1] which shows the position of the various boilers before and after the explosion. As marked on this sketch boilers Nos. 4-A and 4-B were Heine, and Nos. 5, 6 and 7 Stirling. The head of the mud drum of the Stirling boiler No. 6, which blew out, was thinned down by corrosion, but being a blank head, this thinning down was difficult to detect. This head showed a marked indentation, which can be accounted for only by its having been violently struck by something. A study of the accompanying sketch showing the position of the various boilers before and after the explosion shows conclusively that the Heine boiler No. 4-B exploded first, was catapulted end over end to its final position, and in doing so forced Heine No. 4-A into its final position. The shock forced Stirling No. 5 toward the north and demolished the battery wall between Stirling No. 5 and Stirling No. 6, and in so doing a shock was transmitted to the head of the mud drum of Stirling No. 6, which caused it to fracture. Stirling No. 6 was thrown to its final position, and the combined forces of the explosion of Heine No. 4-B and Stirling No. 6, acting from different directions, the force from Heine No. 4-B being greater than that from Stirling No. 6 caused Stirling

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[1] Substantially the same as the map in Fig. 2 on page 433.—Editor.

No. 5 to be carried up and over Stirling No. 6 to the position in which it was found.

Photographs of the parts of Heine No. 4-B and Stirling No. 6 show that the rupture of the Heine boiler was much greater than that of the Stirling, which confirms the conclusion reached in the preceding paragraph. If the initial explosion occurred in Stirling No. 6, it is hardly conceivable that Stirling No. 5 would have been damaged so slightly as has been found to be the case.

No other theory will account for the final position of Stirling No. 5, the drums of which were not ruptured in any way.

The action described above, as having caused the head of Stirling No. 6 to rupture, is precisely the one that took place at the time of the torpedoing of the steamship "Kellog" in July, 1918.

This vessel was fitted with Babcock & Wilcox marine boilers, located three abreast athwartship, thereby presenting the outboard drum head to the side of the ship. The vessel was struck by a torpedo abreast the boilers on the port side, tearing a hole in the ship's side 20 x 40 ft. The 42-in. drum head of the boiler nearest the point struck by the torpedo received the shock which caused it to rupture and blow out. Parts of the ship framing were driven against it as evidenced by many deep indentations. Owing to the original external blow and the resultant internal action, the head was blown to pieces. The head at the other (inboard) end of this drum was badly dented inward, from its impact with the boiler next to it, although the head itself did not rupture. The boiler on which the drum was ruptured was shoved toward the center of the ship, and the two other boilers were moved off their foundations toward the starboard side of the ship, but the drums and pressure parts of these two other boilers were not damaged.

The nature of the explosion was identically the same in both the Mobile Electric Co., and on the "Kellog." At the Mobile Electric Co., Stirling No. 5 was forced toward Stirling No. 6, and the mud drum of Stirling No. 5 or bricks between the mud drum of these two boilers caused a shock to be transmitted to the mud-drum head of Stirling No. 6, indenting it. If the head of Stirling No. 5 had been weaker, that head, rather than that of Stirling No. 6, would undoubtedly have been ruptured; in the shock the weaker head gave way.

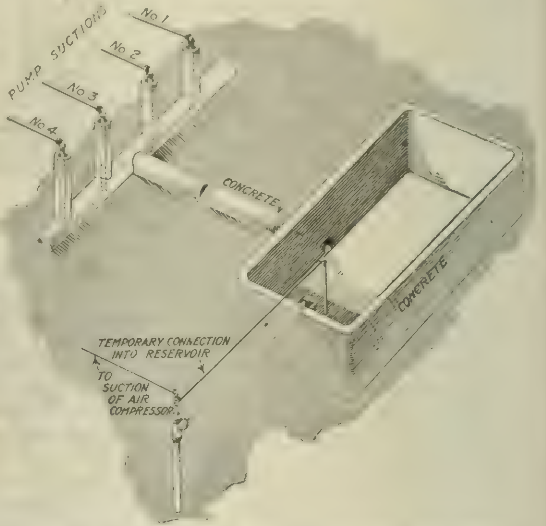
A. G. PRATT,
Second Vice President, Babcock & Wilcox Co.
New York City.

Siphon Emptied Reservoir

During the winter period of overhauling in a California ice plant it became necessary to empty the large concrete reservoir under a cooling tower. No pumping apparatus was available as the boilers were not under pressure during the shutdown period. It was therefore decided by the engineer in charge to make an attempt to siphon the water back into the well from which it had been pumped.

This well was drilled and cased with an 8-in. pipe, inside of which a 2-in. air pipe ran to furnish air for lifting the water. A temporary connection was made from the air line to the bottom of the reservoir, and the original air line was disconnected from the receiver and attached to the suction of a small air compressor. A few turns of the compressor by hand was sufficient to start the siphon working, and the weight of the 100 ft. column of water going down into the well instantly pulled the vacuum-gage hand over to the limit. In a few hours the reservoir was empty

The reason for emptying this reservoir was to enable the engineers to dispense with long individual suction lines to several pumps that had been installed at different times. This was accomplished in the following manner: A ditch was dug on a level with the bottom of the reservoir to the center of the pumproom floor, and a 20-in. cement pipe line was laid with suitable tee connections to allow an individual 12-in. well to be brought up to the base of each pumping unit. This allowed each pump suction to become a very simple affair—one nipple, one ell and an 8-ft. length of vertical pipe extending down into each well so that all leaks and deterioration could be taken care of with a minimum of material and labor. The resistance due to long and comparatively small lines with several ells was thus eliminated. The water flowed by gravity from the reservoir to the pump wells and stood in each well at a level only slightly lower than that of the reservoir itself. The illustration, although not made to scale, shows the features mentioned.


PUMP SUCTIONS
No 1
No 2
No 3
No 4
CONCRETE
CONCRETE
TEMPORARY CONNECTION INTO RESERVOIR
TO SUCTION OF AIR COMPRESSOR

PIPING TO COOLING-TOWER RESERVOIR SHOWING SIMPLE PUMP CONNECTIONS

If this idea is kept in mind while building a new plant and reservoir for possible future pump installations, valuable time and material may be saved when the time arrives for installing additional pumping units.

Pomona, Calif. AMON J. FORTNER.

Our attention has been called to the similarity in principle between the device described by J. M. Purcell in the Feb. 25 issue under the title "Backing Out Broken Setscrew" and a patented device made by the Cleveland Twist Drill Co. under the name of "Ezy-Out Screw Extractor." The essential difference is that Mr. Purcell's device is home-made, from bar stock, whereas the patented device is a finished product made with a taper, although the principle is the same in both cases.—Editor.

Inquiries of General Interest

Evidences of Leaky Condenser Tubes—How does leakage of tubes in a surface condenser become known? L. E.

There will be loss of vacuum from air leakage into the condenser and an excessive delivery of water to the hotwell.

Trouble from Liberation of Air in Suction Pipe—What causes trouble from air in pumping with a suction lift when the suction pipe is tight? W. S. G.

Water under atmospheric conditions contains about 2 per cent. of air in solution, and when the pressure is reduced the air expands. Under a suction lift of 17 ft., if given sufficient time the air would expand to 4 per cent., and with a suction lift of 28 ft. when the pressure would be reduced to an absolute pressure, equivalent to 6 ft. head of water, the air would expand to $34 \div 6 \times 2 = 11.3$ per cent. Ordinarily, the water passes through a suction pipe so quickly that there is not sufficient time for liberation of so much air, but with long suction pipes trouble from liberation of air is more pronounced, because the water is under reduced pressure for a longer time.

Cutting Out Defective Transformer—If three single-phase transformers are connected in delta on the high-tension side and on the low-tension side for diametral connection to a six-phase rotary converter, in case one transformer develops trouble can this unit be cut out and the converter still be operated from the other two transformers? If so what change is it necessary to make in the connections. R. A. C.

The converter may be operated on only two of the transformers. The disabled unit is cut out of circuit on both the high- and low-tension sides, and no changes are made in the connections. This leaves the two transformers in service connected open delta on the high-tension side. The two transformers when connected in open delta, will be able to carry only 58 per cent. of the load of the three transformers when connected closed delta.

Soldering Armature-Coil Leads to Commutator—What is the best method of soldering the coil leads of large armatures to the commutator? What are the objections to using an electric arc or oxyacetylene flame? C. W. R.

The best method of doing the soldering on the commutator of machines of any size is to use a soldering iron. A solder consisting of 50 parts lead and 50 parts tin will have about the correct melting point. The flux best suited for this work is a saturated solution of alcohol and rosin. There are other fluxes that may be used, but many of them will be injurious to the insulation. To do the work to the best advantage, two soldering irons are required, one being heated while the other is in use. The use of an oxyacetylene flame on electric arc for soldering is not practical on account of the temperature being too high and too concentrated. Furthermore, a flame of any kind used for soldering insulated conductors is not to be recommended, because of the difficulty that will be experienced to protect the insulation from burning.

Initial Steam Pressure Too Low for Load—Two boilers have safety valves set to blow at 100 lb., which is not high enough to carry the load on the engine. Another boiler has its safety valve set to blow at 150 lb. How can some steam be taken over from the boiler that is capable of carrying 150 lb. to help out the others? M. F. R.

To raise the pressure of the 100 lb. steam by addition of steam at higher pressure, it would be necessary to perform the mixing intermittently and at periods when there is no communication between the mixing chamber and the source of steam at the lower pressure. The process would need to be similar to admitting steam to a cylinder with cutoff, and subsequently admitting steam of higher initial pressure. Under ordinary plant conditions, the mechanical requirements would be too complex for practical application. The usual method of increasing the effectiveness of steam, by addition of steam at higher pressure, is to perform the mixing by adding the higher-pressure steam throttled down to the lower pressure, as by a pressure-reducing valve, and use the mixture at the lower pressure.

If the engine will not cut off late enough to carry the load when supplied with steam at 100 lb. pressure, the most practical method would be to carry 100 lb. pressure on all boilers; or if that is not feasible, reinforce the 100 lb. steam with steam from the third boiler passed through a reducing valve with a safety valve on the lower-pressure side, large enough to relieve all the steam the higher-pressure boiler is capable of generating at the lower pressure and speed up the engine; or provide large enough cylinder capacity to carry the load with steam supplied at 100 lb. Otherwise it would be necessary to replace the present 100-lb. boilers with boilers capable of supplying steam of higher pressure.

Water-Sealed Stuffing-Box—What is the purpose of a water-sealed stuffing-box, and how is it constructed? W. R.

Water-sealed stuffing-boxes are used for piston rods of pumps employed to obtain a high vacuum, to prevent leakage of air into the pump cylinder. The water sealing consists in keeping the piston rod submerged in water or the atmosphere side of a piston-rod packing. An ordinary stuffing-box, provided it is long enough, can be water-sealed by inserting a lantern *L*, Fig. 1. As shown by the sectional view, the first four rings of the stuffing-box packing are placed in the box, then the lantern, then two more rings. The lantern acts as a separator of the sets of packing rings, and the free space that is left around the rod is connected to the discharge chamber of a water pump or other source of water supply. This prevents air from leaking through the stuffing-box when the latter is only tight enough to prevent leakage of water. Fig. 2 shows the construction of an open water box with two stuffing-boxes, and Fig. 3 shows a modification combining features of Figs. 1 and 2.

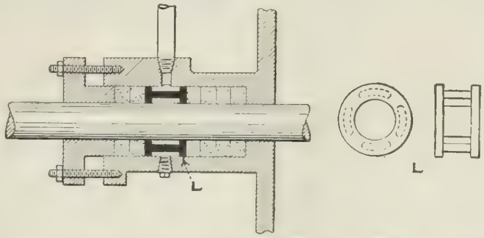


FIG. 1. WATER-SEALED STUFFING-BOX, WITH LANTERN

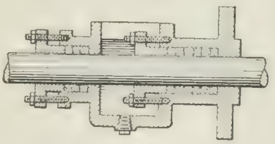


FIG. 2. OPEN WATER BOX

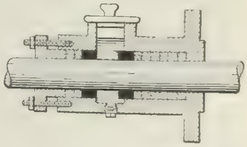


FIG. 3. BOX AND LANTERN

TYPES OF WATER-SEALED STUFFING BOXES

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Turbine Break in Wachusett Hydro-Electric Plant

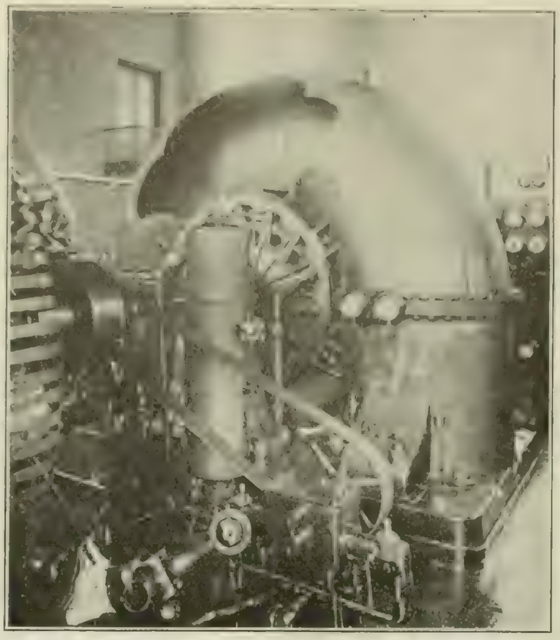


FIG. 1. SHOWING CASING THAT FAILED

AN INTERESTING waterwheel failure occurred in the Wachusett station of the Metropolitan Water and Sewerage Board, at Clinton, Mass., on Feb. 17, which was described by William E. Foss, chief engineer of the board, in a paper before the New England Water Works Association Mar. 12. The Wachusett station, a hydro-electric plant of 4000-kw. rating, which is operated in connection with the supply of water to the Greater Boston system, is located just below the Clinton dam. The hydro-electric machinery is on the first floor, and the second and third floors contain offices for the superintendent and the civil-engineering department respectively. The level of the operating-room floor is about 92 ft. below high water in the Wachusett reservoir.

The plant includes four 1000-kw. 13,800-volt alternating-current generators direct-connected to horizontal-shaft turbines operating at 400 r.p.m., and two 60-kw. 125-volt direct-current exciters, also operated by hydraulic turbines. Each of the main turbines is provided with a type Q Lombard governor arranged for automatic or hand operation as desired.

The water supply for each unit enters the gate chamber through ports in the upstream face of the dam and, after passing the screens, enters a vertical circular well 7 ft. in diameter through two openings, each 6 ft. high and 2½ ft. wide, which are provided with sluice gates arranged for operation by hand or by electric motor. From the bottom of the circular well the water flows through a horizontal 4-ft. cast-iron pipe for a distance of about 115 ft. to a point under the turbines and rises vertically 15 ft. to the base of the scroll case. In the riser is a hydraulic gate valve which can be operated from the power-station floor. When the plant is in operation, energy is delivered to the New England Power Company's system at 13,800 volts, and energy is also furnished at 2300 volts to the Clinton sewage-pumping station. When the plant is not in operation, the energy required is taken from the New England company.

On Feb. 17 the machinery at the plant was started about 6:30 a.m. as usual and had been running smoothly with exciter No. 2 and units Nos. 1, 2 and 4 in operation for nearly an hour, when the operator noticed that the oil-feed pump of turbine No. 2 was not working properly, and with the helper proceeded to prime the pump with the turbine running. Upon throwing off the pump belt, however, some trouble developed and the operator went to the switchboard and threw the load off the No. 2 unit. As he was returning, the helper pulled out the governor clutch to change from automatic to hand control, and immediately a section of the upper portion of the scroll case having an area of 17.5 sq.ft. blew out.

The escaping water knocked the helper down and swept

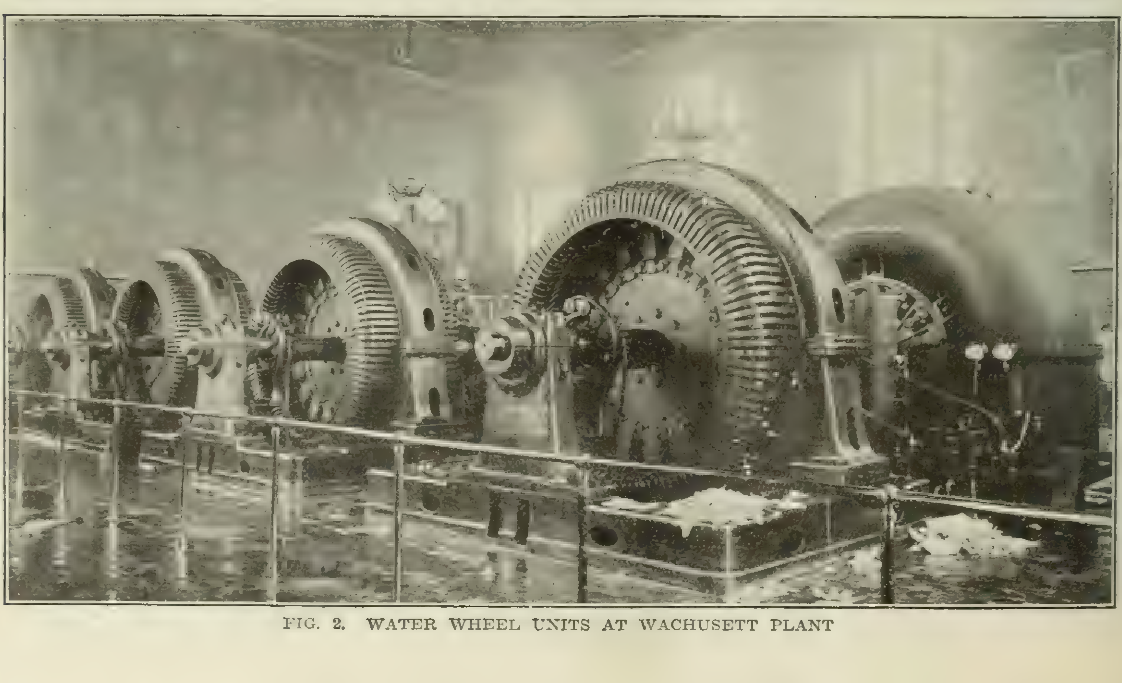


FIG. 2. WATER WHEEL UNITS AT WACHUSETT PLANT

him along the floor between No. 1 and No. 2 generators, by the front door, to a radiator near the westerly end of the station, where he was able to regain his footing, and he left the building through a window. The water was then level with the window sill and about two feet deep over the floor. Meanwhile the operator returned to the switchboard and, after opening all the switches, left the building through the rear door. The two men then went up to the gate chamber and with the assistance of other employees closed the sluice gates and stopped the flow of water about 35 minutes after the break occurred.

The water flowed out of the scroll-case opening under a head of 70 ft., probably in a nearly solid stream, which struck the door leading from the superintendent's office to a small balcony in the power plant, for it is difficult otherwise to account for the effect of the water, which upset a heavy iron safe about 7 ft. high, 4 ft. wide and 2.5 ft. deep and completely wrecked everything else in the office. One of the large windows was broken at a height of about 25 ft. above the floor, and some of the water shot up to the top of the room, broke an interior window, entered the loft and dripped down through the ceiling into the civil-engineering office.

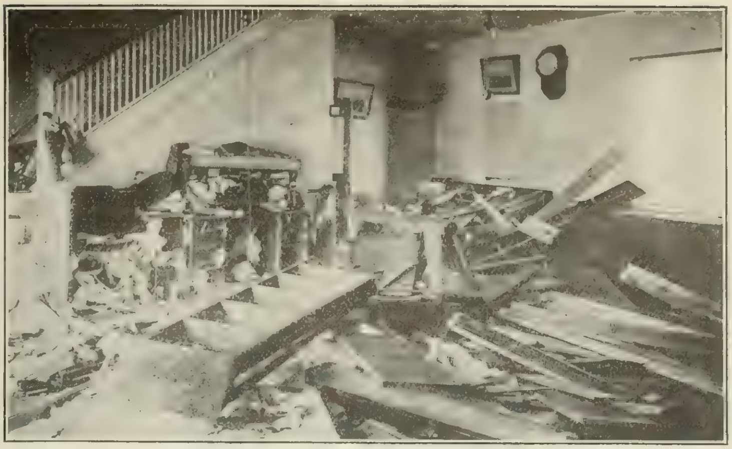


FIG. 3. SHOWING DAMAGE TO OFFICE BY WATER

The water flooded the power station to a depth of about four feet, broke open the front and end doors and flowed out over the lawn, driveway and walks into the river. It also broke down a wooden partition at the air shaft and flowed through the iron grating in the floor into the Wachusett Aqueduct. The heating plant is in a corner of the basement, and there is an opening in the floor above it about 12 ft. long and 6 ft. wide. Water dropped through this opening on the heater and tore off all the magnesia insulation and put out the fire.

The station lighting and power service transformers and many of the instrument transformers were located back of the switchboard near the floor, and the water rose above the top of the cases and displaced the oil, causing short-circuits which grounded all the lines and caused some minor burnouts and insulator breakage on the oil switches. The rotors of generators Nos. 1 and 4 continued to revolve for a time partly submerged in the water, and the insulation of the field and armature coils was cut and scraped in places. The coils on generator No. 2 were also cut and scraped.

As soon as the water had drained out of the building, the heating plant was put into service, and the oil and water were mopped from the floor, walls and apparatus. After running No. 1 exciter generator without load for a time to dry it out by windage, it was put into service to furnish lights, and generators Nos. 1, 3 and 4 were then put in shape and turned over without load during the night to dry them out by windage. On the following day arrangements were made with the Standardizing and Testing Department of the Edison Electric Illuminating Company of Boston for drying out and testing the electrical apparatus. The necessary equipment for this work was shipped from Boston by motor truck late in the afternoon, and the work was started the following morning.

A connection was first made with the New England Power Co.'s line using portable transformer, switching and metering equipment from the Edison laboratory, so that alternating current would be available for drying out and testing the electrical apparatus and for operating the Clinton sewage-pumping station, as the old steam plant there, which had been kept in reserve for emergency use, was not operating satisfactorily. This work was finished on the evening of the second day after the accident and in the meantime canvas had been obtained for covering two of the generators which were being dried out by operating them with armatures short-circuited and a low field excitation; also a motor-driven blower with self-contained heater of electric type was used, and electrically heated ovens were constructed and used for drying out transformers and other apparatus.

Although openings were provided for drainage of electric ducts when these were built into the concrete floor, some of them had become clogged. This made it necessary to disconnect and withdraw the wires in order to dry them out. After the water had been removed from the ducts with swabs, they were dried out by blowing warm air through them. The wires, which had also been dried out, were then replaced and tested.

Pittsburgh Smoke Regulation in 1918

Smoke regulation in Pittsburgh proved of even greater value during the year 1918 than in the preceding four years. The many new conditions presented a much more complicated problem to be worked out in smoke abatement, but progress was made. What the Bureau of Smoke Regulation desires to achieve is to induce people to think what smoke reduction really means. Apart from the fuel saving, reduction of smoke in densely populated areas like Pittsburgh with a low wind velocity, is most important for the preservation of the health and comfort of the inhabitants.

Existing conditions have influenced the owners and operators of plants to advance the following reasons why they should be relieved from the enforcement of the law: 1914, no business; 1915 too much business; 1916, labor scarcity; 1917, war-material production; and 1918 the fuel conditions. That the first four reasons had little standing has been clearly proved, but it required diligence and patience to cope with the fuel situation during 1918. Those plant operators who were so fortunate as to get what coal they needed were required to take any coal they could get. This frequently meant that plants with efficient equipment sufficient to operate their stacks clearly within the ordinance at all times had to contend with great quantities of dirt and refuse in the coal, which precluded the free passage of air through the grates by the formation of slag and clinkers that not only hindered operation but was conducive to smoke and imposed additional burdens on the fireman.

Frequent and justifiable complaints were received during the year about the smoke emitted from public-school buildings. When natural gas was cut off from the schools, serious complications were presented as many of these plants were not competent to burn any other fuel. Therefore, it was necessary to make corrections in plants where the greatest need existed. The Board of Public Education has planned an extensive program that contemplates the revamping of all these plants as soon as possible.

The railroads availed themselves of the lessons taught by their recent strenuous experiences, and even in the face of most exacting fuel conditions adhered to their established plan of supervision and instruction. To appreciate the extent of this undertaking during the past year, it is necessary to contemplate the labor situation, which occasioned the employment of an endless number and variety of firemen, necessitating the teaching of each one the proper method of firing and entailing closer scrutiny on the part of the railroad inspectors.

The number of calls made by inspectors and the time spent inside the plants is indicative of the task devolving upon them, for these, as a rule, were made for the purpose of improving faulty operation in plants where, under normal conditions, the stacks would have been operating without objectionable smoke. The three inspectors made on an average 224 personal visits per month, without taking into consideration the observation of stacks and investigation of complaints. During the year they made 4237 readings or specific observations and 8063 calls.

Complaints received during the year related in a great measure to private residences, and though the regulation of these stacks is not contemplated in the ordinance, each of the 111 complaints received prompt attention. In every instance the nuisance was abated.

As required by Ordinance No. 566, 182 permits were issued to the end of the year 1918, including changes in existing furnaces, new construction and changes in fuel. The fees received for examination of the applications and specifications and covering the issuance of permits amounted to $364. The changes are classified as follows:

CHANGES TOWARD SMOKE ABATEMENT ACCOMPLISHED

No.	Method	Stacks Affected
34	Gas	31
15	Steam jets	13
89	Down-draft boilers	65
191	Smokeless fuel	190
1	Improved stack	1
25	Improved furnaces	22
3	Low-volatile coal	3
6	Smokeless boilers	6
13	Underfeed stokers	10
26	Stokers	17
230	Powdered coal	32
4	Oil	2
1	Down-draft furnace	1
5	Garbage incinerator	5
2	Coke	1
7	Gas and oil	1
2	Coal and powdered coal	1
5	Gas or oil	3
		404

Prosecutions were not made if they could be avoided. Each case had repeated and timely warning and all possible persuasion was brought to bear. These measures failing to get the proper coöperation or evidence of intent to act, suits were entered in twelve cases, all of which had the desired effect, and in every instance the objectionable smoke was abated or such steps taken as to correct the plants permanently.

J. W. Henderson, bureau chief, who had efficiently presided over the affairs of the office for four years and nine months, died on Dec. 19, 1918. W. E. Porter, who had been associated with Mr. Henderson during this time, was appointed to fill the vacancy.

Oil Fuel Versus Coal

Some interesting comparisons between coal and oil as fuels for steam raising were made in a paper read before the Birmingham Association of Mechanical Engineers on Feb. 8. The points in favor of oil in place of coal for warships are: (1) Radius of action increased by 50 per cent. on equal bunker weight, or 80 per cent. on equal bunker space; (2) up to 83 per cent. thermal efficiency instead of 60 per cent.; (3) boilers can be forced up to 50 per cent. above normal rating; (4) control of smoke: entire absence or dense smoke screen as desired; (5) reduction of labor by about 70 per cent.; (6) constructional advantages; (7) bunkering at sea. There are many equally attractive advantages in the application of oil to the mercantile marine. One interesting comparison of coal and oil was made by the American Hawaiian Steamship Co.'s steamship "Arizonan." This vessel took 161 days on the round voyage when burning oil, as compared with 186 days when burning coal, and by economies effected and increased earnings due to saving of bunker spaces and decrease in operating staff, she saved over £4000 on the voyage.

On a comparative test run at Wallsend Slipway with coal and oil on a Scotch marine multitubular type boiler, the following results were obtained, says *The Engineer:*

MEXICAN FUEL OIL

Fuel oil	
Specific gravity at 60 deg. F.	.953
Viscosity at 100 deg. F. (Red. No. 1)	2130 sec.
Flash point (closed)	166 deg. F. (above)
Calorific value	18,430
Water evaporated	
Pounds of water per pound of oil	12.15
Pounds of water per pound of oil (from and at 212 deg. F.)	14.38
Boiler efficiency	73.37 per cent.

COAL

Coal	
Calorific value in B.t.u.	14,432
Water evaporated	
Pounds of water per pound of coal	7.76
Pounds of water per pound of coal (from and at 212 deg. F.)	9.31
Boiler efficiency	62.28 per cent.

Efficiencies as high as 84.5 per cent. have been obtained in this country on Scotch marine type boilers, using Mexican fuel oil with the pressure system of oil burning.

At a large London factory which converted its Lancashire boilers from coal to fuel-oil firing, the water evaporation per pound of coal having a calorific value of 11,451 B.t.u. was 7.22 lb., whereas, when working with the pressure system of oil burning, using an oil having a calorific value of 18,750 B.t.u., the evaporation per pound of oil reached 14.44 lb. The quantity of water evaporated per square foot of heating surface on coal was 3.3 lb., whereas oil showed over 7 lb.—thereby increasing the boiler rating by over 100 per cent.

When utilizing oil fuel, the size of a metallurgical furnace is reduced by 30 per cent., and the working area occupied by a furnace and its adjacent machines is only about 50 per cent. of that of the coal-fired furnace, as a stack of coal occupies a certain amount of space in front of the furnace, and the resultant ashes occupy another space behind the furnace. When using oil fuel these spaces may be utilized as furnace pitches, as the oil fuel is carried through pipelines and does not occupy valuable ground space.

Aluminum is usually melted in what is known as a "lift-out" crucible, and the melted metal carried to the molds, whereas brass is melted in "tilting" furnaces. The average oil fuel consumption for lift-out furnaces, when melting low-fusion metals, is about 15 per cent., and for tilting furnaces about 10 per cent. of metal melted; that is, for every 100 lb. of metal melted the lift-out furnace would consume approximately 1½ gal. of oil, and the tilting type approximately 1 gallon.

A series of experimental mixed-fuel tests was carried out at a large London power station on a nutty slack having a calorific value of 10,300 B.t.u., and Mexican fuel oil having a calorific value of 18,750 B.t.u. A boiler efficiency of 74 per cent. was obtained, and the temperature of the combustion chamber was 2850 deg. F. and uptake 628 deg. F. The proportion of oil to coal on a B.t.u. basis was 8 per cent., and on a weight basis 4.96 per cent.

Southern Section A. S. M. E. Holds Meeting

As this issue goes to press a meeting is being held (Mar. 21) by the Southern Section of the American Society of Mechanical Engineers at Atlanta, the Birmingham, Atlanta and New Orleans Sections participating. The program calls for an all-day session beginning with a visit to the Fulton Bag and Cotton Mills in the forenoon, luncheon at the Piedmont Club, an inspection of Camp Jesup and of the Federal prison in the afternoon, dinner at the Druid Hills Golf Club, and an evening session at the Georgia School of Technology, a paper there being presented on "Pulverized Coal as Fuel" by N. C. Harrison. A large attendance is expected.

The Hydro-Electric Power Commission of Ontario has placed an order with the Westinghouse Co. for two 45,000-kv.-a. vertical waterwheel generators of 12,000 volts, three phase, 25 cycles, for their Queenstown Development. These will be the largest waterwheel generators ever constructed and indicate that the Commission thinks there is no time like the present for construction work.

New Publications

MODEL MAKING. By Raymond Francis Yates. Published by Norman W. Henley Publishing Co., New York. Cloth, 390 pages; 6 x 9 in.; 303 illustrations. Price, $3.

Here is a book for the man of mechanical or scientific bent—whether professional or amateur—who has the time and the patience to indulge in the hobby of model construction. The creative instinct is strong in everyone, and this book shows numerous ways in which that impulse may be satisfied. It opens with a description of the workshop and tools of a model engineer, explains numerous operations and processes that must be performed and then goes to the heart of the matter by giving complete instructions for the making of model steam engines, steam turbines, boilers, boiler fittings, boats, submarine with radio control and various other devices. The directions are stated in a clear style and include not only the operations to be carried out but the sizes and the materials of the various parts as well. The text matter is made still more easily understandable by many clear halftones and working drawings of the various models.

COMPRESSED AIR PLANT. By Robert Peele. Published by John Wiley & Sons, Inc., New York. Cloth, 485 pages; 6 x 9 in.; 246 illustrations. Price, $4.25.

This is the third edition of a work that first appeared in 1908, and deals with the production, transmission and use of compressed air, with special reference to mine service. The first half of the book takes up the structure and operation of various kinds of compressors, the theory of air compression, wet and dry compressors, compound compressors, valves and valve motions, performances of compressors, air receivers, speed and pressure regulators, effect of altitude, explosions in compressors and receivers and compression of air by falling water. The other half describes the methods of transmission and use of compressed air, including piping, compressed-air engines, freezing of moisture, reheating air, rock drills, hammer drills, coal-cutting machines, channeling machines, compressed-air mine pumps, and mine haulage by compressed air. This new edition contains a number of chapters that have been entirely rewritten and expanded and features the most recent changes in the design of compressors, particularly the adoption of thin-plate air valves and larger and more efficient intercoolers on stage compressors.

Personals

Chester Mott has been appointed manager of the Denver (Colo.) office of the Sullivan Machinery Co., at 837 Equitable Building.

James E. Barker, consulting engineer, announces the opening of offices at 611-615 Investment Building, Los Angeles, Cal., for the practice of gas, electrical and mechanical engineering.

Capt. H. A. Weaver, recently discharged from the service, will shortly resume his former position as general manager and chief engineer of the Steel City Testing Laboratories at Pittsburgh, Penn.

E. E. Maher, formerly Western manager for the Lea-Courtenay Co., and more recently for the Terry Steam Turbine Co., has opened up offices in the Michigan Boulevard Building, Chicago, handling various lines of mechanical equipment, including the centrifugal pump of the Dayton-Dowd Co., of Quincy, Ill., high-speed steam engines of the Erie Engine Works, etc. Mr. Maher has had long experience in the mechanical field and is particularly well known in the vicinity of Chicago.

Engineering Affairs

The American Chemical Society will hold its spring meeting with the Western New York Section in Buffalo, Apr. 7-11, with headquarters at the Hotel Statler.

Jersey City N. A. S. E. No. 1 held a dinner on Mar. 15 at Fisher's Hall, at which Lieut. Lewis F. Lyne. Jr., a member, who has been Inspector of munitions, Ordnance Department, gave an interesting and instructive talk with blackboard illustrations, on the subject of "Chemical Warfare." Vice National President John J. Calahan also spoke on the welfare of the association. Twenty-two delegates were elected to attend the New Jersey State convention, which will be held at Bayonne, June 7-8.

Miscellaneous News

The Power Plant of the Monongahela Valley Traction Co. at Rivesville, Marion County, W. Va., now under construction, is nearing completion. Power will be furnished by the plant in question for the entire Monongahela Valley. In putting up the Rivesville plant provision has been made for the construction of additional units as they shall become necessary.

West Virginia Hydro-Electric Power—There will hardly be any hydro-electric water-power development during the next two years in West Virginia for two reasons. In the first place the legislature failed to act on a hydro-electric power bill at the regular session of the body, and although the same bill which was pending during the regular session has again been introduced, as a revenue-producing measure, not having been included in the subjects listed for consideration by Governor Cornwell, it is not considered probable that any action will be taken on the measure at the special session. Furthermore, the bond market is such that it is not considered likely that any attempt will be made to float bonds for water-power development, although all the water power in West Virginia is going to waste.

Business Items

Muskegon Boiler Works of Muskegon, Mich., has opened a district sales office in Chicago, located at 1105 Edison Building, with R. L. Baker as manager.

The United Machine and Manufacturing Co., Canton, Ohio, through an agreement with Charles D. Mosher, has acquired all patents, manufacturing and sales rights covering the Mosher separator.

The Sullivan-Machinery Co. announces the establishment of a branch sales office and warehouse at Edificio Oliver, No. 3, Mexico City. Joseph F. Bennett, who has been for a number of years sales engineer at the company's El Paso office, has been placed in charge of the Mexico branch.

The C. T. Coe Co. has purchased the property of the Hafer Foundry and Machine Co., Chambersburg, Penn., and removed its plant from Newark, N. J., to Chambersburg, where it will continue to manufacture Coe turbine blowers and Coe sectional grates in addition to the Hafer patent soot blowers and Hafer shaking grates; also a full line of boiler specialties.

Trade Catalogs

The Jeffrey Pivoted Bucket Carrier. The Jeffrey Manufacturing Co., Columbus, Ohio. Catalog No. 210. Pages 96, 6 x 9¼ in. Fully illustrated.

Boiler Feed Water Heaters and Purifiers Milwaukee Reliance Boiler Works, Milwaukee, Wis. A 15-page catalog showing different types of boiler feed-water heaters and purifiers.

The Strong Machinery and Supply Co., New York City, has issued a 232-page catalog describing and illustrating its motive power specialties. A 3-page index of the numerous products of this company is appended. Chief engineers will find it a useful reference catalog when purchasing equipment.

The Milwaukee Reliance Boiler Works, Milwaukee, Wis., has recently issued its Bulletin No. 101 on "The Sharp-Bassett Combined Steam and Gas Generator." Pages 23, 8 x 10¾ in. The bulletin describes and illustrates the first and only practical combined steam and gas generator in existence and gives useful information on the application and use of producer gas generally.

New Construction

PROPOSED WORK

Mass., Cambridge—Atwood & McManus, Vale St., Chelsea, will install a steam heating plant and electric power in the 2-story, 90 x 240 ft. box factory which it plans to build on Aberdeen Ave. Total estimated cost, $110,000. J. F. Thomas, 50 Bromheed St., Boston, Engr.

N. Y., Albany—M. Spiegel, Strand Theater Bldg., New York City, will install a steam heating plant in the 2-story, 75 x 175 ft. theater which he plans to build on Monroe St. Total estimated cost, $150,000. T. Lamb, 644 8th Ave., New York City, Arch.

N. Y., Brooklyn—The Beth Moses Hospital, Hart St. and Stuyvesant Ave., will install a steam heating plant in the 5-story, 90 x 100 ft. addition to the hospital which it plans to build. Total estimated cost, $350,000. H. J. Nurich, 957 Bway., Brooklyn, Arch.

N. Y., Brooklyn—Courtney Marshall Estate, Pierpont St., will install a steam heating plant in the 1-story, 100 x 100 ft. theater which it plans to build on Saratoga Ave. and Macon St. Total estimated cost, $100,000. De Rosa & Pereira, 110 West 40th St., New York City, Arch.

N. Y., Carthage—The St. James Parish Building Committee will install a steam heating plant in the 40 x 100 ft. high school which it plans to build on Mechanics St., to be known as the St. James Augustina Academy. Estimated cost, $60,000.

N. Y., New York—J. F. Murray, 33 Clifton Terrace, Weehawken, N. J., has awarded the contract for the construction of an 8-story, 50 x 100 ft. warehouse at 548 West 39th St., to Harby, Abrons & Melius, 15 East 40th St. A steam heating plant will be installed in same. Total estimated cost, $150,000.

N. Y., New York—The National Bible Institute, 213 West 35th St., will install a steam heating plant in the 15-story, 100 x 100 ft. cremorne mission building which it plans to build at 214-216 West 35th St McKenzie, Voorhies & Gmelin, 1123 Bway., Arch.

N. Y., New York—The 181st St. Construction Co., 729 Bway., has awarded the contract for the construction of a 3-story, 150 x 200 ft. theater which it plans to build on Bway. and 181st St., to the Fleishman Construction Co., 39th St. and 7th Ave. A steam heating plant will be installed in same. Total estimated cost, $500,000.

N. Y., Oneida—The Central New York Milk Producers' Association will install a boiler, milk handling machinery etc., in the milk station which it plans to build. Total estimated cost, $12,000. S. T. Bridge, Chn.

N. J., New Brunswick—The Long-Landreth-Schneider Co., 226 Cleveland Ave., plans to build a boiler house and addition to water heater factory. Estimated cost, $10,000. Highland Park Building Co., 238 Cleveland Ave., Arch.

Penn., Philadelphia—E. Wolf, 1517 North 16th St., will install a steam heating system in the 7-story, 75 x 156 ft. store and office building which it plans to build on the Southeast Corner of 16th and Market St. Total estimated cost, $400,000. Hoffman Co., Finance Bldg., Arch.

Md., Baltimore—The Standard Oil Co., Pier 2, Pratt and Commerce St., plans to build a 1-story, 45 x 93 ft. addition to its boiler house on 1st Ave.

D. C., Washington—The Bureau of Yards & Docks, Navy Department, received following bids furnishing condensers, after-coolers and pumps at various Navy Yards; Specification No. 3797:

(1) net price and time for 1 surface condenser, 1 air ejector, and 1 turbine driven condensate pump for a 1000 kw. turbo-generator at the Navy Yard, Portsmouth, N. H.

(2) net price and time for 1 surface condenser, 1 air ejector, and 1 turbine driven condensate pump for an 8000 c.f.m. turbo-compressor, at the Navy Yard, Boston, Mass.

(3) net price and time for 1 surface condenser, 1 air ejector, and 1 turbine driven condensate pump for a 3000 kw. turbo-alternator at the Navy Yard, Philadelphia, Pa.

(4) net price and time for 1 surface condenser, 1 air ejector, and 1 turbine driven condensate pump for an 8000 c.f.m. turbo-compressor at the Navy Yard, Philadelphia, Pa.

(5) net price and time for 1 surface condenser, 1 air ejector, and 1 turbine driven condensate pump for a 3000 kw. turbo-alternator at the Navy Yard, Norfolk, Va.

(6) net price and time for 1 surface condenser, 1 air ejector, and 1 turbine driven condensate pump for an 8000 c.f.m. turbo-compressor at the Navy Yard, Norfolk, Va.

(7) net price and time for 3 surface condensers, 3 air ejectors, 3 motor driven condensate pumps and 3 motor driven circulating pumps for three 1000 kw. turbo-alternators, and 1 air ejector for the priming system, for the Naval Operating Base, Hampton Roads, Va.

(8) net price and time for 1 surface condenser, 1 air ejector, 1 turbine driven condenser pump, and 1 motor driven circulating pump for a 2000 kw. turbo-alternator at the Navy Yard, Charleston, S. C.

(9) net price and time for 1 surface condenser, 1 air ejector, and 1 turbine driven condensate pump for a 1000 kw. turbo-alternator at the Navy Yard, Mare Island, Calif.

(10) net price and time for 1 after cooler for an 8000 c.f.m. turbo-compressor at the Navy Yard, Boston, Mass.

(11) net price and time for 1 after cooler for an 8000 c.f.m. turbo-compressor and a 6500 c.f.m. reciprocating compressor at the Navy Yard, Philadelphia, Pa.

(12) net price and time for 1 after cooler for an 8000 c.f.m. turbo-compressor and a 6500 c.f.m. reciprocating compressor at the Navy Yard, Norfolk, Va.

(13) net price and time for 1 after cooler for a 2500 c.f.m. and two, 500 c.f.m. reciprocating compressors at the Naval Station, New Orleans, La.

(14) net price and time for 1 jet condenser with removal pump and 1 air ejector for a 6000 c.w. turbo-alternator at the Naval Proving Ground and power factory, Indian Head, Md.

(15) net price and time for 2 jet condensers with removal pumps and 2 air ejectors for two, 500 kw. turbo-alternators at the Naval Station, New Orleans, La.

(16) net price and time for 1 jet condenser with removal pump and 1 air ejector for a 2500 c.f.m. and two 500 c.f.m. reciprocating compressors at the Naval Station, New Orleans, La.

(17) net price and time for 1 motor driven booster pump for the cooling water for an 8000 c.f.m. turbo-compressor at the Navy Yard, Boston, Mass.

(18) net price and time for 1 motor driven booster pump for the cooling water for an 8000 c.f.m. turbo-compressor at the Navy Yard, Philadelphia, Pa.

(19) net price and time for 1 motor driven booster pump for the cooling water for an 8000 c.f.m. turbo-compressor at the Navy Yard, Norfolk, Va.

(20) net price and time for 2 turbine driven fire-and-flushing pumps at the Naval Operating Base, Hampton Roads, Va.

(21) net price and time for one, 5000 g.p.m. motor driven circulating pump for the circulating system at the Naval Station, New Orleans, La.

(22) net price and time for one, 2500 g.p.m. motor driven circulating pump for the circulating system at the Naval Station, New Orleans, La.

(23) net price and time for 3 turbine driven boiler feed pumps at the Naval Station, New Orleans, La.

(24) net price and time for 2 turbine driven fire pumps at the Naval Station, New Orleans, La., from

Alberger Pump & Condenser Co., 140 Cedar St., New York City, (1) $10,447 (150 days); (2) $14,750 (90 days); (3) $21,004 (120 days); (4) $19,652 (90 days); (5) $21,112 (120 days); (6) $19,754 (90 days); (7) $47,045 (150 days); (8) $20,411 (150 days); (9) $25,230 (180 days); (10) $3662 (90 days); (11) $8847 (90 days); (12) $8916 (90 days); (13) $3573 (120 days); (14) $21,312 (150 days); (15) $13,480 (120 days); (16) $5049 (120 days); (17) $1684 (90 days); (18) $1414 (90) days); (19) $1447 (90 days); (20) $11,325 (150 days); (21) $4019 (120 days); (22) $2512 (120 days); (23) $5296 (120 days); (24) $8025 (120 days).

Westinghouse Electric & Mfg. Co., 805 Hibbs Bldg., Washington, D. C., (1) $10,984 (150 days); (2) $16,867 (90 days); (3) $22,252 (120 days); (4) $18,838 (90 days); (5) $22,358 (120 days); (6) $18,941 (90 days); (7) $57,695 (150 days); (8) $21,585 (150 days); (9) $31,470 (150 days); (14) $25,428 (120 days); (15) $18,677 (120 days); (16) $6341 (120 days).

DeLaval Steam Turbine Co., Trenton, N. J., (14) $15,766 (180 days); (15) $12,180 (180 days); (16) $4530 (160 days); (17) $1105 (150 days); (18) $1116 (140 days); (19) $1155 (150 days); (20) $10,144 (180 days); (21) $2634 (180 days); (22) $5520 (180 days); (23) $3716 (180 days); (24) $7992 (180 days).

Wheeler Condenser & Engineering Co., 78 Woodward Bldg., Washington, D. C., (1) $11,575 (150 days); (2) $15,400 (120 days); (3) $20,315 (130 days); (4) $19,230 (120 days); (5) $20,380 (130 days); (6) $19,290 (120 days); (7) $55,615 (180 days); (8) $20,820 (150 days); (9) $29,010 (160 days); (14) $21,830 (135 days); (15) $20,510 (120 days); (16) $7675 (120 days); (17) $1450 (120 days); (18) $1380 (120 days); (19) $1380 (120 days).

Ross Heater & Mfg. Co., 1407 West Ave., Buffalo, N. Y., (1) $10,835, $11,115, $12,295 (150 days); (2) $16,340, $16,960 and $17,170 (90 days); (3) $18,860, $19,710 and $19,970 (120 days); (4) $17,925, $18,650 and $18,860 (90 days); (5) $18,010, $19,765 and $19,970 (120 days); (6) $18,025, $18,750 and $18,960 (90 days); (7) $47,150, $48,900 and $49,350 (150 days); (8) $19,710, $20,360 and $20,565 (150 days). (This party bid as given, with 3 amounts to each item.)

Buffalo Steam Pump Co., 490 Broadway, Buffalo, N. Y. (these prices for delivery only, not erection), (1) $6962 (150 to 180 days); (7) $40,186 (180 days); (8) $16,715 (180 days); (17) $1073 (120 days); (18) $1009 (120 days); (19) $1009 (120 days); (20) $7074 (150 to 180 days); (21) $3298 (200 days); (22) $1894 (200 days); (23) $3408 (120 to 150 days); (24) $6436 (165 days).

Ga., Savannah—The Reliance Fertilizer Co., 106 Bay, will install a steam heating plant in the fertilizer factory which it plans to build. Total estimated cost, $100,000. Lockwood Greene, Healey Bldg., Atlanta, Engr.

Fla., Fernandina—N. B. Borden, Chn. of City Council will soon receive bids for enlarging the ice plant.

Fla., Jacksonville—The city plans to purchase a turbo-generator of 10,000 kw. and a condenser of 32,000 sq.ft. capacity. Estimated cost, $226,764.

Ohio, Akron—The Hippodrome Arcade Co., 434 Akron Savings & Loan Bldg., will install heating equipment, consisting of 2 boilers, 2 vacuum pumps, air washers, etc.; in the 2-story, 99 x 136 ft. theater and arcade which it plans to build. Total estimated cost, $100,000. C. H. Crane & E. G. Kiehler, 2325 Dime Bank Bldg., Detroit, Mich., Arch.

Ohio, Cleveland—J. L. Free Co., 1004 Prospect Ave., will install a steam heating plant in the garage which it plans to build on East 9th St. and Bolivar Rd. Total estimated cost, $100,000. M. Dunning, 304 South Wabash Ave., Chicago, Ill., Engr.

Mich., Lansing—The Board of State Auditors will install a steam heating plant, consisting of boilers, pumps, etc., in the 6-story office and library building which it plans to build. Total estimated cost, $800,000. E. A. Bowd, 127 Allegan St., West, Arch.

Mich., Wakefield—The Board of Education will install steam heating and mechanical ventilation systems in the 2-story, 65 x 150 ft. school building which it plans to build. Total estimated cost, $100,000. Nystrom & Olsen, Palladio Bldg., Duluth, Minn., Arch.

Mich., Wakefield—The Board of Education will install steam heating and mechanical ventilating systems in the 2-story, 80 x 175 ft. manual training and recreation building which it plans to build. Total estimated cost, $150,000. Nystrom & Olsen, Palladio Bldg., Duluth, Minn., Arch.

Kan., Oswego—The city plans election April 1 to vote on $50,000 bond issue for the construction of a new lighting plant.

Kan., Uniontown—The city plans to install an electric lighting plant.

Mo., St. Louis—The McQuay Norris Manufacturing Co., 2808 Locust St., plans to build a power house, in connection with the factory which it plans to build on Cooper St. and Oak Hill R. R. A. J. Mummert, 2808 Locust St., Engr.

CONTRACTS AWARDED

N. Y., Thiells—L. F. Pilcher, State Arch., Capitol, Albany, has awarded the contract for installing steam and heating plant equipment in the Central Heating plant at Letchworth Village, to the Merrill Co., 98 Granite St., Boston, Mass. Estimated cost, $46,984. Noted Jan. 21.

Ohio, Norwood—The Board of Education has awarded the contract for installing steam heating and ventilating systems in the 2-story, 80 x 139 ft. school on Allison St., to the Stanton Heater Co. Estimated cost, $15,170. Noted Jan. 28.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8 05@8 35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2 15@2 75	$2 80@3 50
Philadelphia, gross tons	4 20@4 90	5 00@5 55
New York, gross tons	4 50@5 25	5 35@5 95
Alongside Boston (water coal), gross tons	6 10@6 85	6 90@7 80

Pocahontas and New River are quoted at $4 70@5 25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7 20@8 60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5 95	$7 80	Pea	4 80	6 55
Egg	5 85	7 70	Buckwheat	3 40	5 15
Stove	6 10	7 95	Rice	2.90	4.65
Chestnut	6 20	8 05	Barley	2 40	4.15

Bituminous

	Spot	Contract
South Forks	$2 90 @ $3 50	$3 10 @ $3 50
Cambria County (good grades)	2 80 @ 3.00	2.95 @ 3 00
Clearfield County	2.65 @ 2.95	...
Reynoldsville	2.65 @ 2.95	2.85 @ 3 00
Quemahoning	2.85 @ 3.10	2.95 @ 3.10
Somerset County (best grades)	2.80 @ 2.95	2.95 @ 3 10
Somerset County (poorer grades)	2.50 @ 2.75	2.75 @ 2 95
Western Maryland	2.50 @ 2.75	2.65 @ 2.85
Fairmont	2 10 @ 2.35	2.35 @ 2.50
Latrobe	2.25 @ 2.40	....
Greensburg	2 35 @ 2.40	... ...
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2 40 @ 2.65	2.40 @ 2 65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.30	Buckwheat	$3.40	$4.45
Egg	5.85	7 20	Rice	2.90	3.80
Stove	6.10	7 45	Boiler	2.70	3.70
Nut	6.20	7 55	Barley	2.40	3.30
Pea	4.80	6.05	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.75	$3.25
Mine-run	2.35@$2.50	3.00
Screenings	2.05	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

	Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2 75	. .	. .
Williamson County Prepared sizes, lump, egg, nut	$2 55	$2 55	$1 90@2 25
Mine-run	2.20	2.20	1.60@1.70
Screenings	2.05	2.05	.95@1.10
3-in. lump	....	2.30	....
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St. Louis is $1.10 other rates 92½c.

POWER

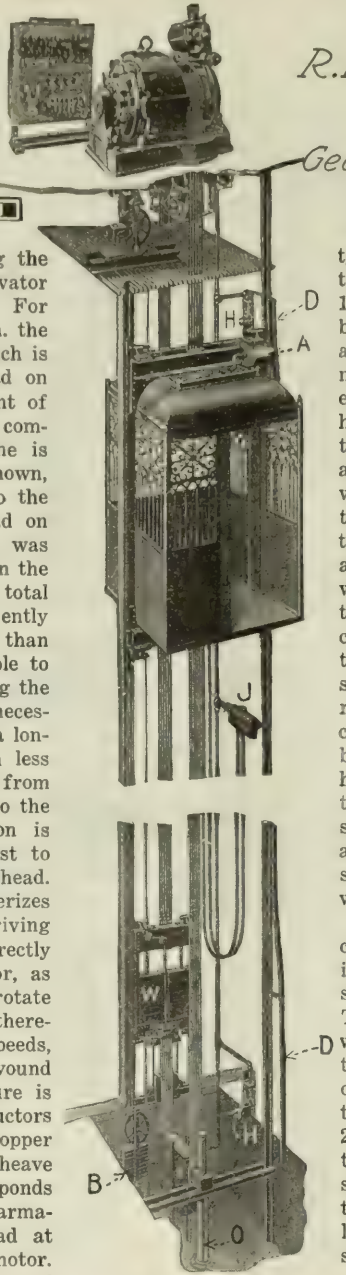
Volume 49 New York, April 1, 1919 *Number* 13

Two Methods of Persuasion

The Operation of a Gearless Traction Elevator

The Parts of a Direct-Traction Elevator Machine and their Functions

By
R. H. Whitehead, M.E.
Engineer with
Geo. W. Goethals & Co. Inc.



A COMPLETE installation using the 1:1 gearless-traction type elevator machine is shown on this page. For a duty of 2500 lb. at 700 ft. per min. the machine weighs about 16,000 lb., which is considerably less than the total load on the hoisting ropes, due to the weight of the counterweight, car, hoisting and compensating ropes. When the machine is placed on the overhead beams, as shown, the load on the building is equal to the weight of the machine plus the load on the hoisting ropes. If the machine was placed below, as in Fig. 3, the load on the overhead sheaves would be twice the total load on the hoisting ropes, consequently as the weight of the machine is less than the hoisting-rope loads it is desirable to place the machine overhead. Locating the machine overhead also obviates the necessity for extra sheaves, consequently a longer rope life is obtained and much less roping is required, as will be apparent from a comparison of Figs. 1 and 3. Also the over-all efficiency of the installation is higher. Therefore it is always best to locate gearless-traction machines overhead.

The particular feature that characterizes this type of installation is that the driving sheave and brake wheel are pressed directly on the armature shaft of the motor, as indicated in Figs. 1 and 5, and hence rotate at the motor's speeed. The motor therefore must be built for very slow speeds, and generally has six or eight poles wound with shunt field only. The armature is series wound with rectangular conductors to get the maximum amount of copper in the armature slots. With a 36-in. sheave a car speed of 600 ft. per min. corresponds to 63.6 revolutions per minute of the armature. To handle a 2500-lb. carload at this speed requires about a 38-hp. motor. The dimensions of the motor are several times larger than those of a machine of this horsepower built for 600 revolutions per minute. With the standard type of traction machine it is necessary to use a secondary or idler sheave *F*, Figs. 1, 2 and 5, so that the hoisting ropes can be given approximately two half-wraps around the driving sheave to obtain the necessary traction. In general six $\frac{5}{8}$-in. extra-flexible steel ropes are used for hoisting. As shown in the illustration on this page and also in Fig. 1, these ropes are led from the car to the driving sheave, where they make one half-turn, then to the idler or secondary sheave and back to the driving sheave for another half-turn, and then to the counterweight. In cases where the driving sheave does not span the center-to-center distance between the car and counterweight, as shown in Fig. 1, the secondary sheave *F* must be offset, as shown in Fig. 2, and used also to lead the ropes from the driving sheave to the counterweight. Consequently, in practice both the driving and secondary sheaves have 12 grooves cut in them. With the two half-turns around the driving sheave, slippage will not occur between the ropes and the sheave until the load on the car side is about twice that of the counterweight size, or vice versa.

The counterweight, which includes the counterweight buffer, is adjusted so that it equals the total weight of the car and sling, plus 40 per cent. of the car load. Thus, for a duty of 2500 lb. the counterweight would weigh 1000 lb. more than the car and sling. With compensation as obtained by compensating ropes, shown in the complete installation and Figs. 1 and 2, the maximum difference between the tension on the counterweight and the car side of the hoisting ropes is 1500 lb. As the total load on both sides exceeds 16,000 lb., as mentioned previously, and as slippage will not occur until the load on one side is twice that of the other, it can be readily seen that the traction is positive and that there is no danger of slippage. In fact, the traction is as positive as if the ropes were wound on a spirally grooved drum, which would be impossible on account of the large amount of rope required, due to the high rise.

The adjustment of the hoisting ropes must always be maintained so that, if the car should overrun the bottom landing, the counterweights will not run into the overhead work, even after the combination oil and spring bumper, Figs. 1 and 2, in the pit is fully compressed, or if the car should overrun the top terminal landing, the counterweight bumper will strike its bumper blocks in the pit. If either the car or counterweight bottoms in the pit, the traction between the driving sheaves and ropes is lost. This makes the traction type of machine the safest of all modern elevators, as there is no danger of the car or the counterweights being drawn into the overhead work, even if the machine continues to run. An exception, however, occurs in very high rises when the great weight of the hoisting rope will cause considerable traction, even after the car or counterweight has landed on its bumper. This traction, together with the momentum of the car or counterweight, might cause either of them to run into the overhead work, especially where the overhead clearance is small. To prevent this, some of the high-rise installations are equipped with retarding devices, which come into action after a normal overrun is exceeded, and cause sufficient unequal loading on the hoisting cables at the driving sheave to create slippage and stop further motion.

In the complete installation and Figs. 1 and 2 compensating ropes are shown attached to the bottom of the counterweight and to the bottom of the car sling. It will be noticed that these ropes travel around a compensating sheave located in the pit at the bottom of the elevator shaft. This compensating sheave is free to move vertically, its housing being designed so that it can move up and down between guides in the pit. The compensating sheave and the housing are of heavy construction, so as to keep the compensating ropes under proper tension. This sheave also acts as a safety device, since, if either car or counterweight bottoms, further motion lifts the sheave and housing and thus tends to stop the car or counterweight from running into the overhead work. In addition, a switch is generally provided, which is opened when the sheave is lifted up a short distance. This switch in turn opens the main contactor *M* on the control board, Fig. 5, and stops the motor.

The hoisting and compensating ropes are each provided with self-adjusting swivel hitches of the ball-and-socket type, as indicated in Figs. 1 and 2. This permits

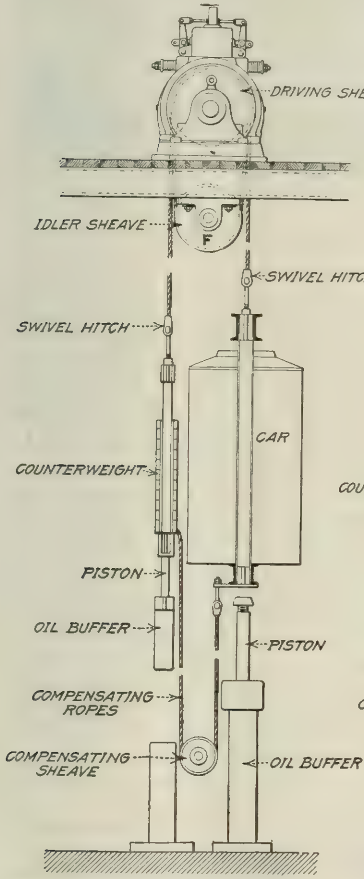


FIG. 1. INSTALLATION WHERE DRIVING SHEAVE SPANS HALF THE CAR WIDTH

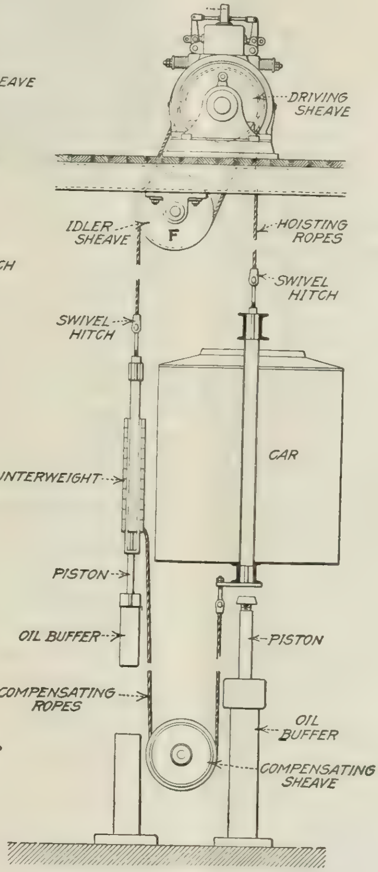


FIG. 2. INSTALLATION WHERE DRIVING SHEAVE DOES NOT SPAN HALF THE CAR WIDTH

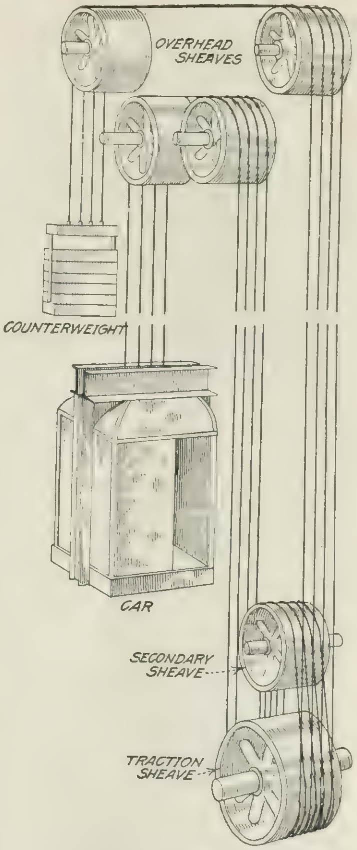


FIG. 3. INSTALLATION IN WHICH THE MACHINE IS LOCATED IN THE BASEMENT

of a gradual twisting or creeping of the ropes and prevents twisting strains at the hitches. In practice the ropes creep, owing to vibration and travel around the sheaves.

The compensating ropes compensate for the variation in the net load on the driving sheave, due to the shifting of the weight of the hoisting ropes from one side to the other that occurs during motion of the car up and down the hoistway. The weight of the compensating ropes must be such per foot that they will, with the electric cables leading to the car, compensate for the net shifting of load due to the weight of the hoisting ropes, regardless of the position of the car in the hoistway. Fig. 4 gives a sectional view of the oil-spring buffer used, as previously described, in the hoistway under the car and counterweight to assist in bringing them to rest in case the car overtravels the top or bottom landings. The retardation of the car or counterweight is brought about when either comes down on its buffer by the escape of oil from one chamber into the other of the buffer, through holes in the inner chamber indicated in the figure. When the buffer is unloaded, its piston is returned to its normal position by a spiral spring. The buffer is so constructed that it will bring the car to rest from full speed, when loaded, without discomfort.

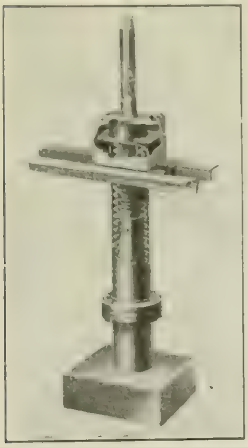


FIG. 4. COMBINATION OIL-SPRING BUFFER

The brake wheel is generally of the same diameter as the driving sheave. The brake *B* is operated by a solenoid *S*, Fig. 5, so arranged that when the motor is energized the solenoid is also energized, and lifts the brake shoes off the brake wheel, against the tension of the brake springs *T*, by means of levers attached to the brake shoes and solenoid's cores. Inasmuch as, when the brake shoes are once lifted less current is required to hold them off the brake wheel, the solenoid's core levers operate a small switch *W* on top of the brake, which inserts a resistance in series with the solenoid to cut down the amount of current after the brake has been opened. The brake-shoe springs *T* are adjusted so that when the brake solenoid is not energized the pressure of the brake will hold full-load motor torque. With the slow-speed motor of 60 r.p.m. this torque is ten times as much as for a 600-r.p.m. motor of equal horsepower. Consequently, the brake must be of very heavy construction. Safe-lift machines for lifting heavy safes, etc., have two brakes, as shown in Fig. 6.

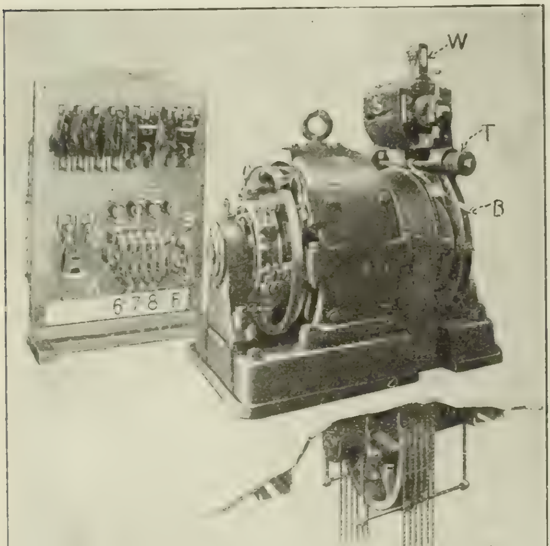


FIG 5. GEARLESS-TRACTION ELEVATOR MACHINE

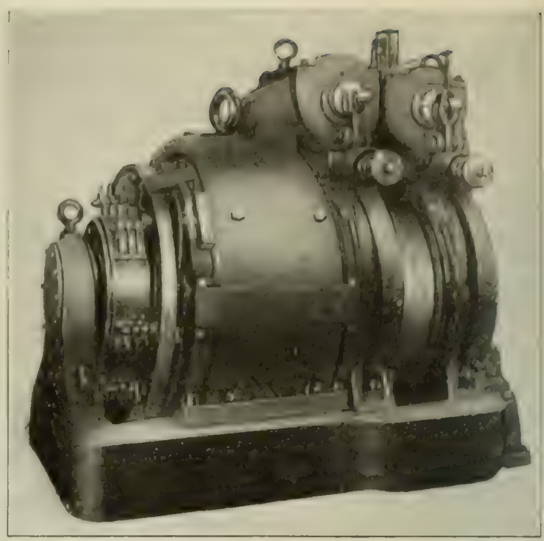


FIG. 6. TRACTION MACHINE WITH TWO BRAKES

In the most modern elevator installations an electromechanical type of safety is used on the car and a mechanical type of safety on the counterweights. The details of these safeties are shown in Figs. 7, 8 and 9. Fig. 7 gives the general scheme of roping up the governor to the car and counterweight safeties, Fig. 8 the details of the electro-mechanical safety on the car, and Fig. 9 the counterweight-safety details. A description of the operation of the safeties is as follows:

Starting from the governor *G*, Fig. 7, the governor rope *R* is deflected by the two small sheaves at the top of the counterweight so that it leads straight down and around the counterweight-safety sheaves *S*, Fig. 9, making two full turns, then it is deflected off the counterweight by the two small sheaves at the bottom of the counterweight to the governor-tension sheave *B*, Fig. 7. The governor-tension sheave at the bottom of the pit is counterweighted, as shown at *B* in the complete installation, to keep the proper tension on the rope. This sheave is free to move vertically, the movement being controlled by guides in the pit. After leaving the tension sheave, the rope runs up to the car and is deflected by small idlers under the car, Fig. 7, to the car-safety sheave. After making two full turns around the safety sheave *S*, Fig. 8, the rope is led by idler sheaves to a releasing carrier on top the car and thence back to the governor *G*, Fig. 7.

During normal operating conditions the safety sheaves *S* remain stationary and the governor rope also remains stationary with respect to the car and counterweight. The motion of the car and counterweights causes the governor rope to rotate the governor *G* and the tension sheave *B*. A releasing carrier on the car prevents motion of the sheaves *S* until a heavy pull on the governor rope releases the carrier. When the governor is rotated above a predetermined speed, the balls of the governor open a switch which controls a magnet whose contacts are in series with the magnet under the car, shown at *A*, Fig. 8. When this magnet is deenergized, the spring *C* causes the jaws *D* to apply a light retarding force on the rails *E* and thus brings the car gradually to a stop.

In case, however, the hoisting ropes part, the downward motion of the car and counterweight causes the governor rope to rotate the safety sheaves *S*, Figs. 8 and 9, and this in turn causes the safety jaws *D* to clamp the rails and stop the car, and the safety jaws *J* to clamp to the counterweight guide rail and stop the counterweight.

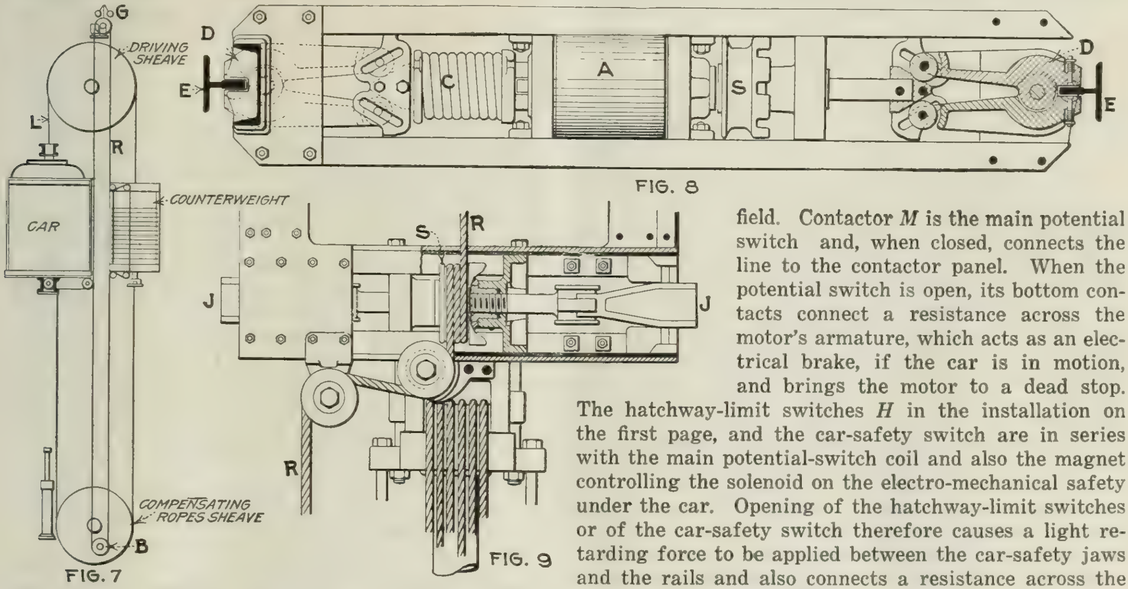


FIG. 7 FIG. 8 FIG. 9

FIGS. 7 TO 9. DETAILS OF CAR AND COUNTERWEIGHT SAFETIES

The controller panel for the motor is operated by a car switch in the car, under control of the elevator operator. The control-circuit conductors are placed in conduit between the controller and a junction box *J* at the center of the hatch, shown in the complete installation, and flexible cables containing the conductors are provided from this junction box to the bottom of the car platform, where they are led in conduit to the car switch.

The gearless-traction elevator-machine motor is shunt-wound, and its field winding is always excited as long as the line switch is closed. The field connections are made direct to the line so as to eliminate possible opening of the field circuit and overspeeding the motor.

To secure proper control, it is necessary to provide for slow speed and for acceleration to be gradual. For slow speeds it is necessary not only to use resistance in series with the armature, but to use a resistance across the armature, so as to obtain proper speed control. In starting a gearless-traction elevator, the minimum bypass resistance is connected across the armature, and the maximum resistance in series with the armature and bypass resistance. The bypass resistance is increased in steps by the closing of contactors 1, 2, 3 and 4, Fig. 5. When contactor 4 operates, the bypass resistance is opened, leaving only the series resistance in circuit. Contactors 5, 6, 7, 8 and 9 are operated automatically by a single magnet *A* connected across the motor's armature, which is energized by the closing of an auxiliary contact on contactor 4. As the armature comes up to speed, the voltage across it increases; this increases the pull of the magnet, and as the pull increases, contactors 5, 6, 7, 8 and 9 operate successively, each cutting out of circuit a section of the series resistance. When contactor 9 closes, the motor is placed directly across the line. The speed is still further increased by the opening of the fast-speed magnet *F*, which puts a resistance in series with the motor's field. Contactor *M* is the main potential switch and, when closed, connects the line to the contactor panel. When the potential switch is open, its bottom contacts connect a resistance across the motor's armature, which acts as an electrical brake, if the car is in motion, and brings the motor to a dead stop. The hatchway-limit switches *H* in the installation on the first page, and the car-safety switch are in series with the main potential-switch coil and also the magnet controlling the solenoid on the electro-mechanical safety under the car. Opening of the hatchway-limit switches or of the car-safety switch therefore causes a light retarding force to be applied between the car-safety jaws and the rails and also connects a resistance across the armature, consequently the car is quickly brought to rest.

The up-and-down contactors *U* and *D*, Fig. 5, are mechanically interlocked and arranged so that they pass the current through the armature to give proper direction of rotation of the motor. The car switch controls the solenoids on the up-and-down contactors *U* and *D*, the slow-speed magnets 1, 2, 3 and 4 and the fast-speed magnet. The operator is consequently able to run the car at any desired speed.

On the top of the car is an automatic stopping switch *A*, shown in the complete installation. This switch has a number of contacts which are successively opened by movement of the switch arm coming in contact with bent angle irons *D* at the top and bottom of the hatchway, called slowdowns. When the car approaches near to the terminal landing, the roller on the stopping arm comes into contact with the slowdowns and continued motion of the car causes movement of the stopping arm and opening of the contacts in switch *A*. The first contact closes the fast-speed magnet and slows the car down; the second, third and fourth gradually reduce the motor's speed by opening the magnets 4, 3 and 1; and the last contact opens the up or down reversing switch, as the case may be. Further details of gearless-traction elevator control will be given in a later article.

Summing up, the safety devices of the gearless-traction elevator are as follows:

1. Automatic return of the car switch to an off position.

2. The automatic-stopping switch gradually brings the car to a stop as the top or bottom landings are approached.

3. The hatchway-limit swtches operate if the car continues to move after the automatic stopping switch opens the reversing switches.

4. The switch operated by the centrifugal governor stops the car in case of overspeeding, by causing a light retarding force to be applied between the car-safety jaws and rails and opening the main potential switch.

5. The oil buffers are capable of stopping the car or counterweight at 50 per cent. excess speed without discomfort to passengers.

6. After the car or counterweight strikes the bumpers, the traction between the hoisting cables and driving sheave is either lost or greatly reduced.

7. Overtravel beyond the top terminal landing lifts the compensating sheaves and housing, and this in turn helps to decrease the traction and also operates a switch to stop the motor.

8. Opening of the car-safety switch stops the motor and applies a light retarding force between the car safety jaws and rails, thus stopping the car.

9. For high-lift elevators a mechanical retarding and latching device is provided to stop the car from overrun beyond the top-terminal landing.

10. Breaking of the hoisting ropes causes the application of a heavy retarding force on the car and counterweight safeties.

Proper Packings Produced Savings

By Waldo Weaver

My experience in paper mills and rubber plants has made it apparent that too many engineers are penny wise and dollar foolish in the purchase of packings.

The following will demonstrate my contention: The engines driving the heaters and jordans were invariably shut down two or three times weekly to pack the cutoff-valve stems. As a ten-minute shutdown in a paper mill means a loss of one hour on the paper machines, it is obvious that such shutdowns result in a drop in production, amounting in this case to from $100 to $200 weekly. After trying out several packings, one was secured that made it certain that the engines would not have to be shut down from this cause.

It was also necessary to pack the piston rods every second week so that the engines could be operated continuously from Monday morning to the next Sunday morning. It was a regular Sunday job in our case to slaughter about three boxes of soft coil packing, costing about $21. Metallic packings were applied, which saved the company over $500 the first year. A similar condition existed in a rubber mill with the addition that a shutdown of the main engine resulted in a much greater loss in production and profits. The kind of packings which had been found so satisfactory in the paper mill were purchased and applied.

In this rubber mill there was no end of trouble with the outside-packed power and hydraulic pumps. It was an every Sunday job to pack these pumps, and it cost the company considerable for labor as well as for packing. Various combinations of cut rings were experimented with and finally such combinations selected as gave the longest wear without repacking and did not produce a detrimental wear on the plungers. Some of these pumps were operated for more than a year without repacking. In one instance the pump was not repacked in three years. The life of packings depends on the construction and workmanship of the pump, dust in the surrounding air, etc.

Some years ago I suffered a shutdown in a small central-station plant because of a broken hard-rubber valve in the large boiler-feed pump. As the smaller pump would not hold the water up in the boilers on the peak load and as the large pump could not be put back into service at once because the repairman broke the stud off in removing it, it was necessary to drop nearly half the service. This cured me of that kind of pump valve. I use nothing but special composition valves which, although expensive, are worth the money, as they will outwear four to five sets of the ordinary rubber valves, and besides do not require replacing so often. I have not found brass valves satisfactory.

Care should also be exercised in the selection of pump valves used with condensers. The first cost of such valves can be considerably reduced by using thinner ones; besides, thin valves will wear longer than thick ones as the lift can be made less, also the spring tension.

Considerable slippage results in high-pressure pumps and fire pumps because the valves are too hard. Inside-packed pumps will give much less trouble and the slippage will be less if special solid or uncut duck rings are used. Rock-hard duck should be used on hot water. Valve-stem packings should likewise be given special attention. Shredded metal gives the best results when used in combination with a good grade of soft twist packing. Certain brands of twist packings are far superior to others that are said to be of the same combination. This is especially true where superheated steam is encountered.

Many engineers seem to think the packing on centrifugal pumps requires little attention, yet last winter I witnessed a tremendous loss in a large rubber mill due to this oversight, resulting in the destruction of many quite expensive brass sleeves. Naturally, the labor expense for replacing these sleeves was of far greater importance than the cost of the sleeves. One centrifugal handling 12,000 gal. per min. to a condenser had been in operation about a year, yet the sleeves had grooves worn in them over one-half inch deep. This was also true of a new boiler-feed centrifugal. It was all uncalled for, but the engineers passed it by as only a small thing

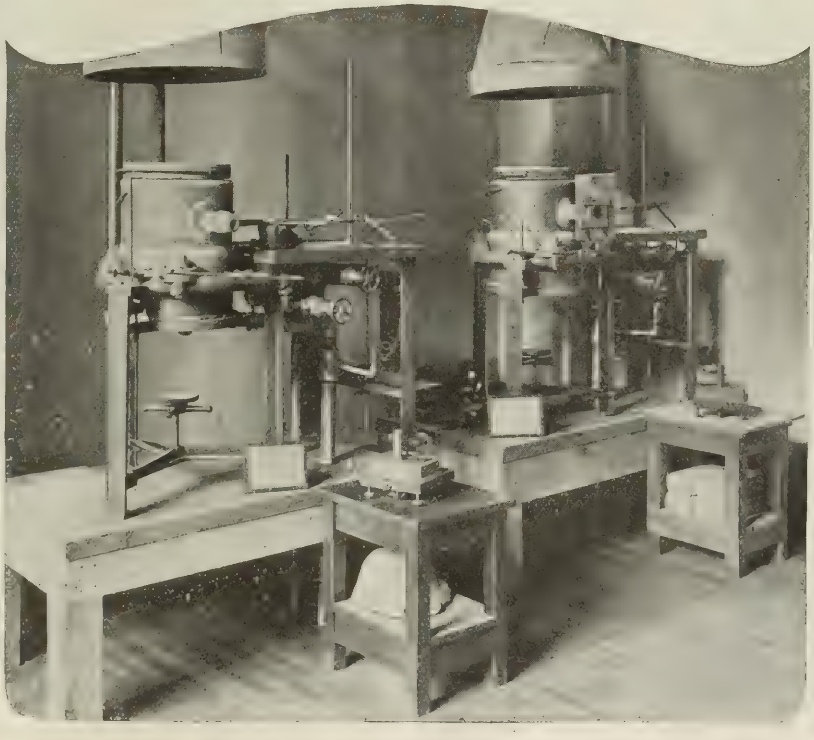
Special attention should be given to the packing of centrifugals used in connection with condensers where the pump lifts its water. This is true even though the glands are water-sealed. In one case the vacuum was increased 1.7 in. by keeping these glands tight on the circulating water pump. The rise in vacuum resulted from increasing the water circulated. The speed of the pump was not augmented.

Packings are only one of the many things that require special thought and intelligence and serve to make the engineer either a success or a failure, and will pay the owner good dividends in several ways if given proper attention.

Fusibility of Ash from Great Lakes and Mississippi Valley Coals[*]

BY W. A. SELVIG, W. C. RATLIFF, AND A. C. FIELDNER

Some of the most valuable of the articles on clinkers and the fusion temperatures of ash appearing in "Power" are: "Fusion Temperatures of Ash," by Bailey and Calkins, Nov. 8, 1910; "Fusion Temperatures of Ash," by Wing (discussion of the previously mentioned article), Dec. 27, 1910; Reply to Wing by Bailey, Feb. 7, 1911; "Fusing Temperatures of Coal Ash," Bailey, Nov. 28, 1911; "Clinkering Properties of Coal," Hubley, Dec. 1, 1914; "The Clinkering of Coal," Professor Marks, Dec. 29, 1914; "Cause and Prevention of Clinker," Bureau of Mines, Aug. 31, 1915; "Clinkering of Bituminous Coal," Hubley, a series of four unusually valuable articles, Oct. 10, 17, 24 and Nov. 7, 1916. "Fusibility of Coal Ash from West Virginia Coals," W. A. Selvig, Oct. 15, 1918.



FURNACES USED TO DETERMINE FUSION TEMPERATURES OF ASH

THE Interior coal province which includes all of the bituminous coal fields near the Great Lakes, in the Mississippi Valley, and in Texas, contains a vast amount of coal which is extensively mined and has been an important factor in the development of the manufacturing centers of this region. While there is a large amount of analytical data available as to the composition of these coals[1], there has been no general survey of the fusibility of the ash from the various coal beds comprising this coal province. The Bureau of Mines is making fusibility tests on the well-known American coals, and this paper gives a summary of such tests on the coals of the Interior province A previous paper[2] of the Bureau of Mines gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash fusibility tests, together with a summary of such tests on West Virginia coals. Analyses of clinkers from boiler furnaces indicated that the conditions were such as to form clinkers in which the iron is present principally in the ferrous state, consequently the values obtained in the laboratory tests are in this respect comparable to the actual fuel-bed conditions, and give the lowest temperatures at which the intimately mixed ash softens with the formation of clinker. The tables of fusibility of coal-ash tests give the average values for all mines tested in each coal bed. Average values for each mine were computed from the individual samples, which in practically all cases are standard mine samples collected by representatives of the Bureau of Mines, the United States Geological Survey, or by the various state geological surveys, according to the methods used by the Bureau of Mines[3]. A small number of car samples that were considered representative of the output of the various mines are also included.

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[*] Abstract of a paper on Fusibility of Coal Ash from the Interior Province Coals as compared with West Virginia Coals. Published by permission of the Director, United States Bureau of Mines.

[1] Lord, N. W., and others, "Analyses of Coals in the United States, with Descriptions of Mine and Field Samples Collected Between July 1, 1904, and June 30, 1910"; Bull. 22, Bureau of Mines, 1913, 1200 pp. (In two parts).
Fieldner, A. C., and others; "Analyses of Mine and Car Samples Collected in the Fiscal Years 1911 to 1913"; Bull. 85, Bureau of Mines, 1914, 444 pp.
Fieldner, A. C., and others; "Analyses of Mine and Car Samples Collected in the Fiscal Years 1913 to 1915"; Bull. 123, Bureau of Mines, 1917, 456 pp.
Parr, S. W.; "Chemical study of Illinois Coals; Illinois State Geological Survey, Coal Mining Investigations"; Bull. 3, 1916, 86 pp.

[2] Selvig, W. A.; "Fusibility of Coal Ash from West Virginia Coals; *Power*, Oct. 15, 1918, p. 566; *Chemical and Metallurgical Engineering*, Vol. 19, No. 12, 1918, p. 826. For a complete table giving results obtained for each mine tested, see: Selvig, W. A.; "Fusibility of Coal Ash from West Virginia Coals"; *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16.

The point taken as the softening temperature is that at which the ash when molded into solid triangular pyramids ¾ in. high and ¼ in. wide at the side of the base, and mounted in a vertical position, has fused down to a spherical lump. Points at which the tips of the cones first fuse and at which the ash has become very fluid are also taken and serve mainly as an indication of the viscosity of the melting ash; however, these values are not given in the tables. The average percentage of ash and sulphur, on the dry coal basis, is given as a basis of comparison of the different beds.

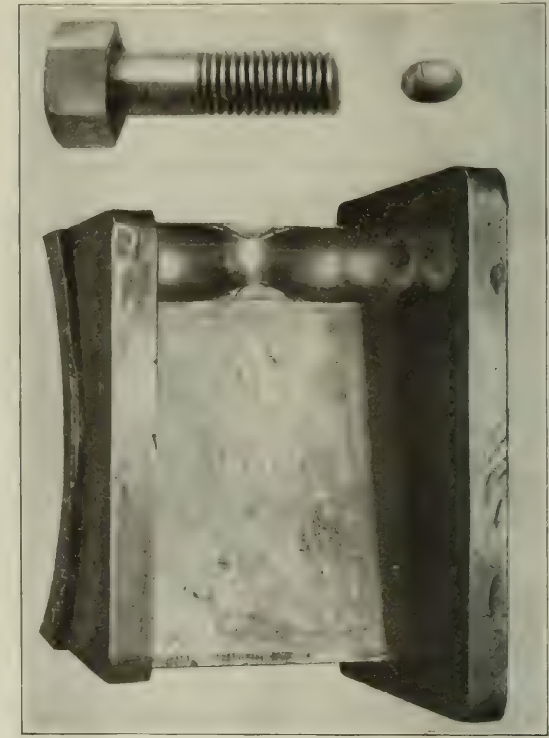
TABLE 1 FUSIBILITY OF COAL ASH FROM THE INTERIOR PROVINCE COALS

Region, State, Bed 1	Number of Mines Sampled 2	Total Number of Samples 3	Average Softening Temperature, Deg F 4	Ash in Dry Coal, Average Per Cent. 5	Sulphur in Dry Coal, Average Per Cent. 6
Eastern Region:					
Illinois					
No. 1 Bed	1		2110	11.74	4.86
No. 2 Bed	6	15	2010	9.97	3.58
No. 5 Bed	9	27	1990	10.84	3.28
No. 6 Bed	36	160	2160	10.27	2.30
No. 7 Bed	2	13	2050	10.62	2.69
Indiana					
No. 3 Bed	3	11	2090	10.61	4.34
No. 4 Bed	7	30	2390	8.17	1.62
No. 5 Bed	9	29	2130	10.23	3.54
No. 6 Bed	1	5	2040	9.91	2.65
Minshall Bed	1	1	2120	9.60	2.99
Western Kentucky					
No. 6 Bed	1		2130	8.81	2.97
No. 9 Bed	20	78	2030	10.53	3.67
No. 10 Bed	2	2	1990	11.99	4.18
No. 11 Bed	7	39	2030	9.57	4.08
No. 12 Bed	3	17	2150	10.20	2.30
Western Region:					
Kansas					
Bevier Bed	2	6	1980	14.83	4.71
Cherokee Bed	3	8	2110	9.42	3.18
Leavenworth Bed	1	3	2020	18.26	5.46
Weir-Pittsburgh Bed	3	7	2010	11.68	5.31
Missouri					
Bevier Bed	16	42	1960	13.47	4.90
Bowen Bed	1	3	1940	13.18	4.61
Cainsville Bed	1	3	1980	12.71	5.78
Cherokee Bed	1	3	2150	7.51	1.97
Jordan Bed	4	12	2010	12.74	4.42
Lexington Bed	14	39	2000	13.48	4.04
Lower Rich Hill Bed	3	8	1940	15.39	5.43
Lower Weir-Pittsburgh Bed	2	6	1940	10.78	4.45
Mulberry Bed	2	5	1990	14.58	3.18
Mulky Bed	4	9	1940	11.28	5.25
Rich Hill Bed	1	3	1970	15.47	6.12
Tebo Bed	8	23	2040	11.64	4.66
Waverly Bed	1	2	2020	17.43	8.29
Oklahoma					
Dawson Bed	3	3	1920	8.95	3.91
Henryetta Bed	2	2	1980	8.03	1.59
Lehigh Coal Bed	3	15	2150	11.46	4.17
Lower Hartshorne Bed	9	27	2020	6.03	1.43
McAlester Bed	6	28	2180	6.94	1.67
McCurtain Bed	1	6	2110	6.92	0.84
Panama Bed	2	4	2160	6.81	1.46
Stigler Bed	5	5	2050	5.13	1.91
Upper Hartshorne Bed	3	7	2170	6.15	1.51
Arkansas					
Denning Bed	1	3	2200	7.38	2.45
Hartshorne Bed	5	9	2120	11.59	1.40
Paris Bed	1	3	2140	10.12	3.28
Shinn Basin Bed	1	1	2180	10.36	2.23
Southwestern Region:					
Texas					
Santo Tomas	2	2	2580	19.21	1.98

What a Broken Wedge Bolt Did

Broken wedge bolts are not uncommon in reciprocating-engine practice, and sometimes the result is somewhat curious. One recent instance was that of an 18 x 36-in. Corliss engine running at 106 r.p.m. 24 hours per day, with the exception of Sunday, when a small engine was used for the necessary light and power during the week-end shutdown.

One morning the chief engineer in making his round noticed that there was an accumulation of brass in the oil pan underneath the crankpin, but the night engineer, on being questioned, disclaimed having had any trouble with a hot brass, and that the engine was running all right was evident. On Sunday, when the engine was shut down, the chief had the crankpin brasses removed. He was surprised to find that two depressions on the back of the brass next to the wedge had been worn, also on either side of the brass flanges. These are shown in the illustration, also the broken adjusting bolt; the egg-shaped portion is what is left of the broken-off end of the same bolt.


CRANKPIN BRASS WORN BY BROKEN WEDGE BOLT

During the night shift the top wedge bolt broke. The engineer took out the longer section of the bolt and managed to remove the broken end from the wedge, but neglected to remove it from the space between the wedge and the top of the crankrod. As there was nothing to prevent putting in a new wedge bolt and adjusting the bearing, this was done and the engine was started up and ran along as usual. The piece of adjusting bolt that was left in the space between the adjusting wedge and the crankrod was about ¾ in. long, and in bouncing back and forth with the throw of the crank it was worn egg-shaped, the threads entirely disappeared and the bearing brass was worn as shown.

Although there is nothing peculiar in the action of this broken wedge bolt, it is a very good example of what constant pounding will do even with a light stroke. The time the broken piece of bolt was being knocked back and forth was about one month.

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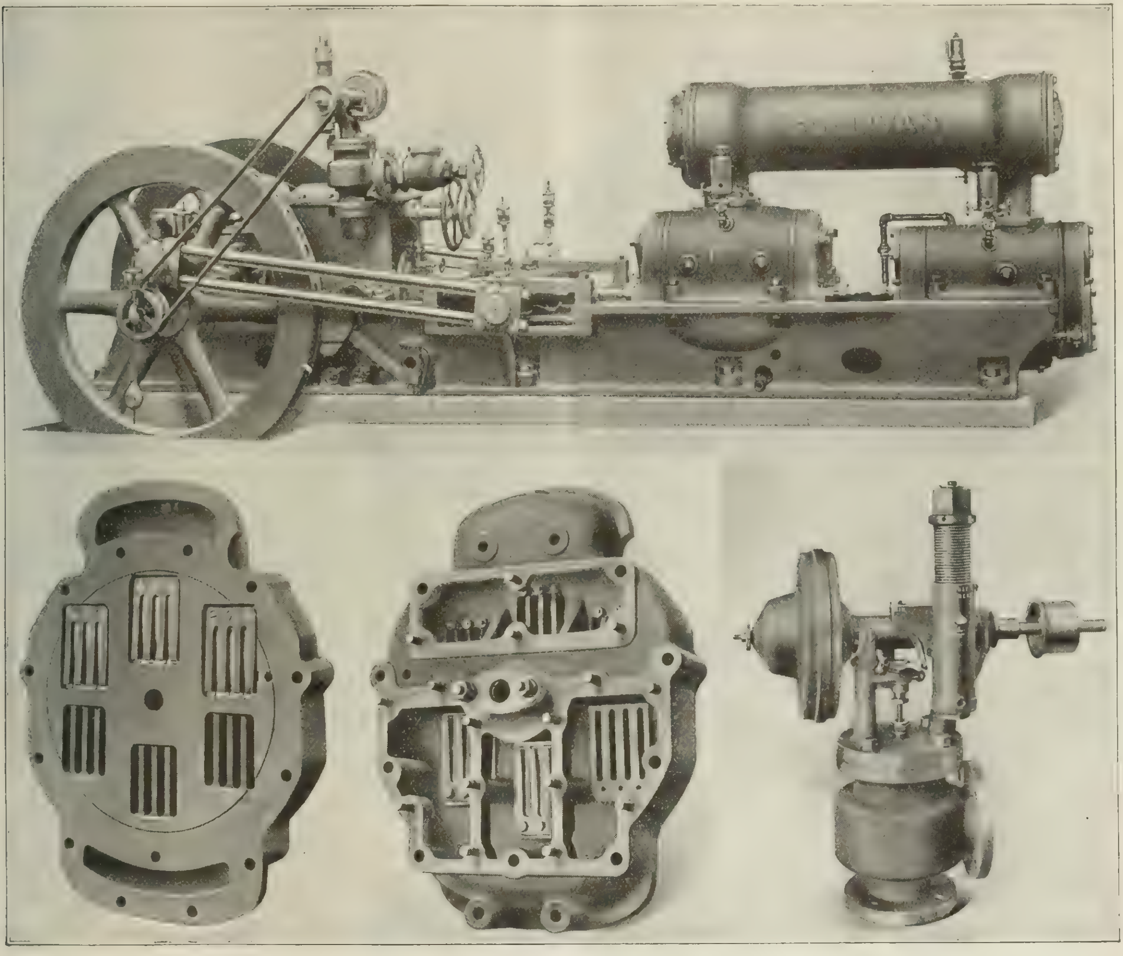
[3] Holmes, J. A.; "The Sampling of Coal in the Mine"; Technical Paper 1, Bureau of Mines, 1911, 18 pp.

Plate Valves for Sullivan Straight-Line Compressors

During the last year a radical improvement has been made in the design of the Sullivan straight-line steam-driven two-stage air compressor. For the semirotary or Corliss mechanically driven air inlet valves, formerly applied on these machines, the new type of Sullivan plate valves has been substituted. These valves, which are similar in design to those in successful use for the last two years on Sullivan angle-compound compressors, are shown in the illustrations. They are designed to secure rapidity of action, wide port opening with minimum wiredrawing effect and a reduction in the power required to operate them. The loss from clearance and leakage in this design is comparatively low, so that high volumetric efficiency is secured.


SHOWING SULLIVAN STRAIGHT-LINE, TWO-STAGE AIR COMPRESSOR: INSIDE FACE OF CYLINDER HEAD, CYLINDER HEAD WITH VALVE COVERS AND SOME OF VALVES REMOVED, AND COMBINED SPEED AND PRESSURE REGULATOR WITH SAFETY STOP

The finger valve, as it is called, is of a distinctive grid form, shaped like a group of thin flat fingers or blades and made from sheet spring steel. It is bolted at one end only to a steel guard plate, the other end being free. This guard plate is curved to form a rest for the entire length of each blade, when it is bent or lifted by the incoming or outgoing air. In lifting, under air pressure, the fingers exercise a rolling or rocking action against the guard, opening first at their outer end. When closing, the fingers roll back to their seats, the fixed end closing first and the free outer points last. This action eliminates hammering and insures noiseless operation. The valves seat over rectangular ports in the face of the cylinder heads. The inlet valves are situated in the upper half of the head, and the discharge valves, which are of the same design, in the lower half.

Other improvements in the compressor are a simplified steam valve mechanism controlled by a Meyer adjustable cutoff and the Judson type of combined speed and pressure regulator fitted with a safety stop. The speed-controlling element is located at the end of the horizontal shaft shown in the illustration. For protection against dirt it is inclosed in a casing. Three adjustments are provided—maximum speed, minimum speed and air pressure—each of these being independent of the other. Where the demand for air is intermittent, an automatic unloading valve is provided to supplement the action of the governor.

The compressor is built in capacities ranging from 400 to 950 cu.ft. of air per minute.

United States Nitrate Plant No. 2 at Muscle Shoals—Main and House Turbines

BY CHARLES H. BROMLEY

This is the first complete description of the triple-cylinder, pure-reaction parallel-flow turbine to be published. The Muscle Shoals machine, which is the most interesting of this new type, is of 60,000-kw. continuous capacity. Its flexibility of control is one of its paramount features. Performance data are given and the sequences of operations of control and signal systems are explained.

THIS is the second of a number of articles treating of this interesting power plant. The main turbine unit is of the reaction, cross-compound, triple-cylinder parallell-flow type. While there is similarity between this 70,000-kw. maximum unit and the latest machine installed in the Seventy-Fourth Street Station, New York City, the former is perhaps the most interesting turbine. As the triple-cylinder or compound-type unit has had to date only meager description, it is fitting that the machine be quite fully described here. The writer is appreciative of the cooperation of the purchasers, the Air Nitrates Corporation, and the builders, the Westinghouse Electric and Manufacturing Co.

The turbine installation consists of a single unit having a capacity of 60,000 kw. continuous and a maximum of 70,000 kw. for short periods. It consists of a single-flow high-pressure turbine operating at 1800 r.p.m., and two semi-double-flow low-pressure turbines operating at 1200 r.p.m., and three generators of equal capacity. The turbine is of the pure-reaction three-cylinder 88-stage type. It is designed to divide the load equally between the three generators at 60,000 kw. The overall dimensions are: Length, 53 ft. 8 in.; width, 56 ft. 2 in.; height, 19 ft. 3 in. The shipping weight is 2,600,000 lb., and the heaviest piece for the crane is 142,000 lb. Fig. 1 shows an end elevation of the machine.

Steam at 275-lb. pressure and 175 deg. F. superheat is admitted to the single-flow high-pressure element through two 18-in. steam headers, each equipped with an 18-in. combination throttle valve. These are united into a 26-in. inlet, entering the turbine through a governor-controlled, oil-relay-operated, double-balanced poppet valve. Steam strainers are provided in each of the 18-in. headers. In emergency either one of these headers may be taken out of service without affecting the operation of the unit except to reduce its maximum capacity to about 50,000 kw. The exhaust from the high-pressure turbine is divided equally between the two low-pressure turbines. The receiver pressure, which varies almost directly with the load, is 62 lb. abs. at 60,000 kw. The inlet to each low-pressure is 32 in. in diameter and is provided with a gate valve and an automatically controlled butterfly valve so arranged that when the valves are closed either high-pressure or low-pressure turbine may be entirely dismantled while the other is in operation. These receiver pipes are supported on springs, a detail of which is shown in Fig. 1, thus relieving the turbines of stresses other than those caused by temperature changes, though most of these latter are cared for by the expansion joint. The butterfly valves may be operated automatically or manually.

There is an atmospheric relief connection to the bottom of the high-pressure turbine adjusted to open when the receiver pressure reaches aproximately 80 lb. abs. This valve protects the receiver pipe against excessive back pressure in case of one or both of the automatic butterfly valves on the low-pressure turbines closing. It also protects the low-pressure turbines against excesive load in case the high-pressure turbine is automatically cut out of service and the low-pressure turbines operated on high-pressure steam. There is also an atmospheric relief valve on the exhaust from each of the low-pressure turbines to protect the condensers and exhaust piping against excessive pressure should the condensers, for any reason, fail.

Each low-pressure turbine is provided with a 14-in. high-pressure steam supply under governor control. It is, therefore, practicable to operate either of the three turbine elements alone on high-pressure steam or to operate the high-pressure turbine together with either one of the two low-pressure turbines.

The high-pressure turbine is provided with an overspeed governor to close the two 18-in. main throttle valves and the governor controlled inlet valve in case of overspeed. Each low-pressure turbine is similarly equipped with an overspeed governor which closes the butterfly valve in the 32-in. low-pressure steam-supply line and also the 14-in. throttle valve in the high-pressure steam supply. Either of these overspeed mechanisms may be quickly tripped by hand. This provides a means of almost instantly shutting off all steam supplied to either turbine element.

The high-pressure element is small and made almost entirely of steel on account of the high temperatures and pressures involved. The blades are large and strong and their velocities low. The steam velocities are only about one-third higher than those of the blades, thus reducing the steam-friction losses to a minimum and preventing erosion. In the high-pressure element the smallest blades are 4 in. high by 1 in. nominal width while the largest are 9 in. high by 1¼ in. in width. In the low-pressure elements the shortest blades are 4 in. high by ½ in. nominal width, and the largest 18 in. high by 1¼ in. in width. The low-pressure blading is relatively lighter than the high-pressure because of the lesser steam densities.

The total expansion from throttle pressure to condenser pressure is divided into 88 stages or pressure drops, 44 of these taking place in the high-pressure element and an equal number in the low-pressure elements. The turbine is designed for highest efficiency at 50,000 kw., which load is carried on the primary valve. Overload capacities of 60,000 kw. and 70,000 kw. are obtained by means of bypassing a few of the high-pressure stages by means of secondary and tertiary overload valves, shown in Fig. 3. At 50,000 kw. the secondary valve begins to open; and at 60,000 the ter-

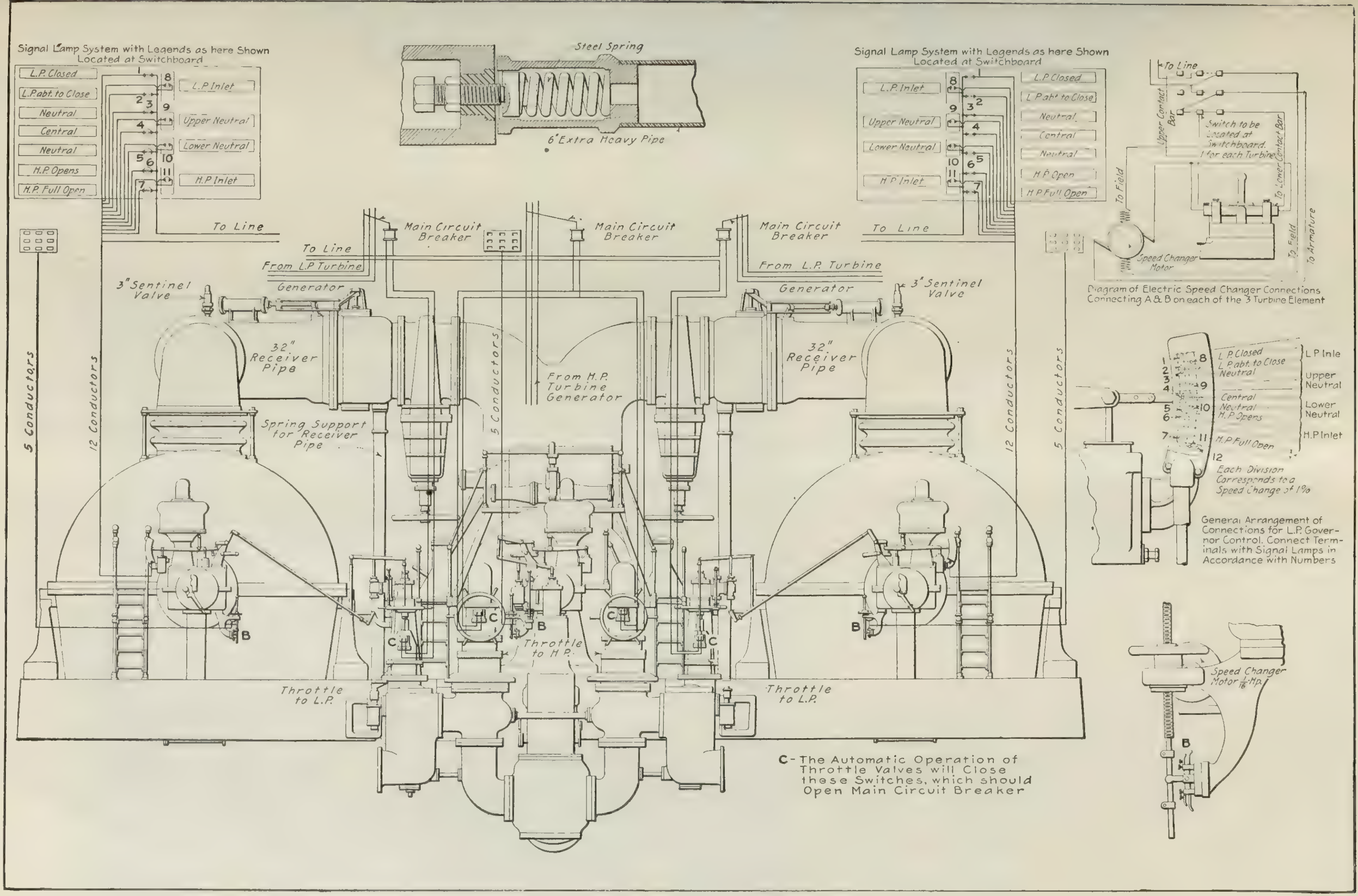


FIG. 1. END ELEVATION OF 60,000-KW. COMPOUND TURBINE, SHOWING DETAIL RECEIVER-PIPE SUPPORT AND WIRING DIAGRAM OF SIGNAL AND CONTROL SYSTEMS

tiary begins to leave its seat; the primary valve is wide open at about 53,000 kw., while at 70,000 kw. all valves are wide open. The turbine cylinders are carried on separate supports or chairs, as nearly as possible on a level with the horizontal center line. To maintain proper alignment independent of cylinder temperatures, such as occasioned by varying loads and vacuum, and to permit free expansion of the cylinder without distortion, the large exhaust chambers of the low-pressure turbines particularly are heavily ribbed and braced to secure adequate rigidity and maintain proper clearances and alignment under extreme fluctuations of temperature and vacuum. The turbine foundation during construction is shown in Fig. 2.

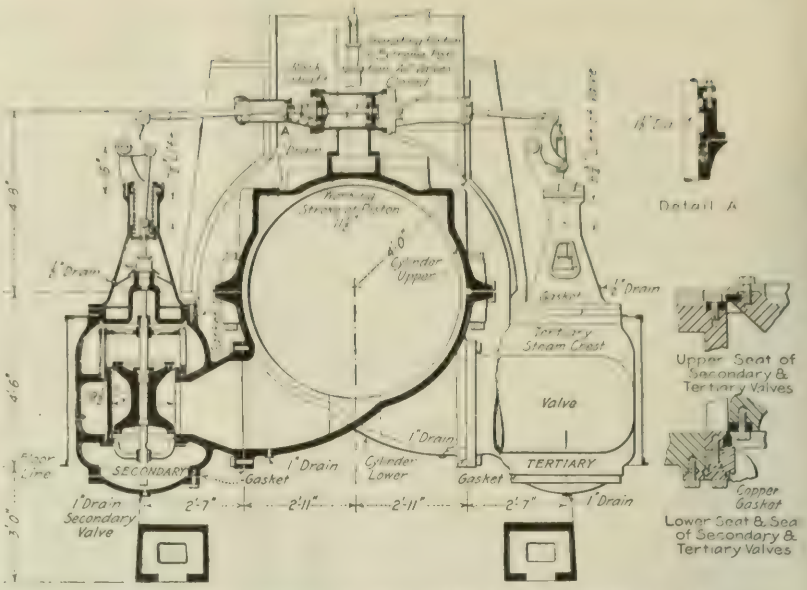


FIG. 3 ARRANGEMENT OF SECONDARY AND TERTIARY VALVES

At 50,000 kw. the secondary begins to open and at 60,000 kw. the tertiary leaves its seat; the primary is full open at 53,000 kw. and at 70,000 kw. all three valves are wide open.

Clean and tight seals between turbine cylinder and rotating shaft are secured by means of combination steam labyrinth and water glands. In the high-pressure turbine, where the steam pressure on the inside of the cylinder is high, the steam labyrinth is continually in service; a leak-off to the low-pressure being provided between the steam labyrinth and the water gland, the water gland simply preventing leakage of steam to the atmosphere or leakage of air into the leak-off. On the low-pressure turbine the glands seal only against vacuum. The water glands only are normally in service. The steam labyrinth is employed to permit establishing vacuum on the condensers while starting. An essential feature is that with both the steam labyrinth and water glands there is no mechanical contact between the rotating and stationary elements, and consequently practically no deterioration.

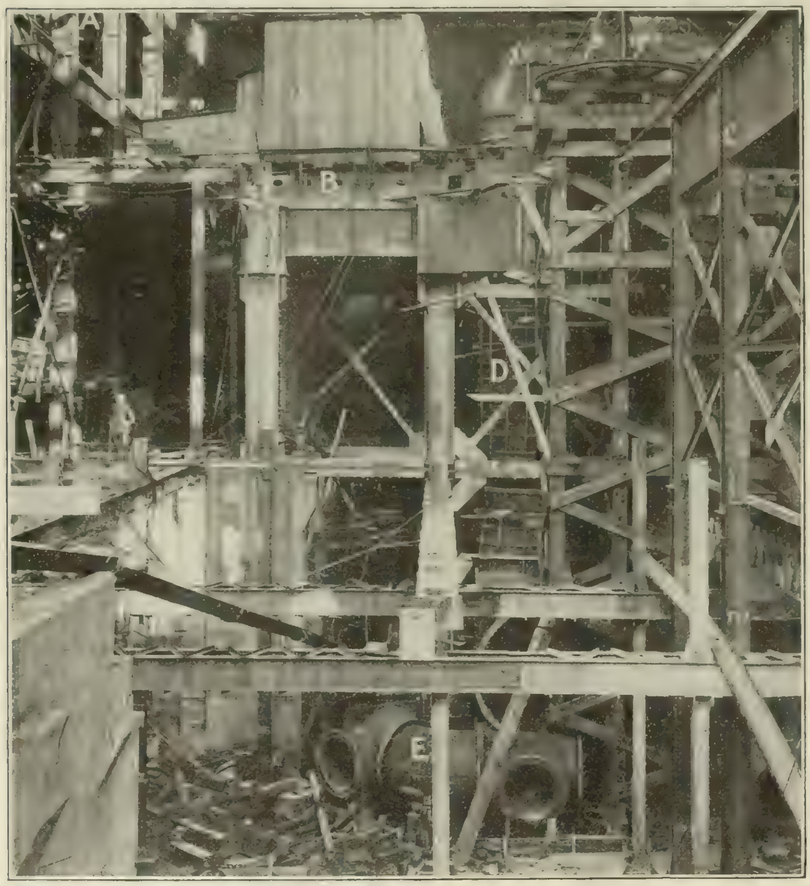


FIG. 2. VIEW OF TURBINE FOUNDATIONS DURING CONSTRUCTION

Locate the man at the left to get an idea of the magnitude of this work. *A*, electrical galleries; *B*, bedplate; *C*, house-turbine foundation; *D*, exhaust connection; *E*, 60-in. pipe.

Each turbine element is equipped with a reciprocating-type oil pump, Fig. 4, geared from the main rotor. Each pump is provided with doubled opposed plungers and delivers oil from two discharge openings at different pressures. The high-pressure side has a plunger 3¼ in. in diameter and pumps against 60 lb. pressure with a capacity of 29½ gal. per min. The low-pressure side has a 4-in. diameter plunger pumping against 5 to 8 lb. pressure, with a capacity of 44.8 gal. per min. The oiling system, Fig. 5, is arranged so that normally the three pumps discharge into common high-pressure and low-pressure systems. Provision is made, however, for easily cutting out of service either pump, or the oil supply to either turbine element. The high-pressure discharge leads directly into the surge tank from which all the oil-operated governor valves are supplied. The low-pressure discharges lead directly into the oil coolers, together with the high-pressure oil which has either passed through the oil relay operating cylinders, or the spring-loaded bypass valves. From the coolers the oil is distributed to the bearings, thence back to the reservoir through the strainer.

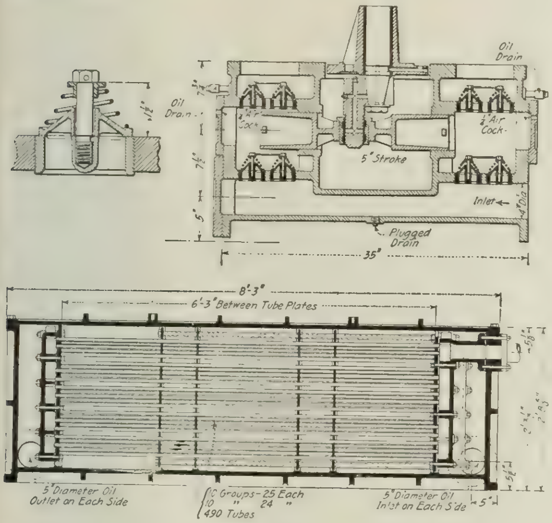


FIG. 4. OIL PUMP AND COOLER, 60,000-KW. TURBINE

Each turbine element has one of these reciprocating pumps in parallel discharging into common high- and low-pressure systems. Each high-pressure plunger delivers 29.5 gal. per min. against 60 lb. pressure; each low-pressure plunger, 44.8 gal. per min. against 5 to 8 lb. Oil coolers; Two used; totaling cooling surface, sq. ft., 1200. Each cooler has 490 brass, 0.75-in tubes in 10 groups of 25 each and 10 groups of 24 each, baffled to give 5 passes; water passes serially through tubes, making total of 20 passes.

A diagrammatic layout of the oiling system is shown in Fig. 5; it is quite self-explanatory. The oil strainer or filter has capacity for 1500 gal. per hr. and the reservoir a much larger capacity. The oil cooler, shown in section in Fig. 4, has been designed with a view to giving excellent performance even after having been in service for a long period without cleaning; that is, there is a liberal cooling area. There are 490 brass tubes ¾-in. diameter No. 18 B.w.g., 6 ft. 3 in. long between tube sheets, giving 600 sq.ft. total cooling surface, baffled to give five passes and assembled in 10 groups of 25 tubes each, and 10 groups of 24 each. The cooling water passes serially through each group, making a total of 20 passes. There are two such coolers. The oil overflow and vent box, shown in section in Fig. 6, indicate the quantity of oil in the system and provide an automatic means of discharging from the system oil taken from the bottom of the reservoir equal in quantity to the fresh oil added, thus enabling continuous operation of a partial filtration system without dependence of operation of the turbine on the satisfactory operation of the filtering system with respect to the quantity of the oil supply. There are two oil coolers, Fig. 4, normally operated in parallel, but so piped that either one may be taken out of service for cleaning without disturbing the operation of the system, the arangement of valves being such that it is impossible to shut off the oil supply to the bearings by improper manipulation of the valves. The hotwell water, of which there is about 200,000 lb. per hour and which is at a temperature varying from 68 deg. F. to 100 deg. F., assists in cooling the oil supply. The oil imparts heat enough to the water to increase its temperature to about 130 deg. F. The automatic control system permits either turbine element being automatically or manually cut out of service without disturbing the operation of the other two elements. The main generator busses are divided into three sections, joined only by reactance coils. Each section of bus is energized by one of the three generators, circuit-breakers being provided between the generator and the bus section. In case of a heavy short-circuit on a section of the bus or the feeders leading from it, the circuit-breaker between that section and the generator supplying it will open. In case the circuit-breaker opens on either of

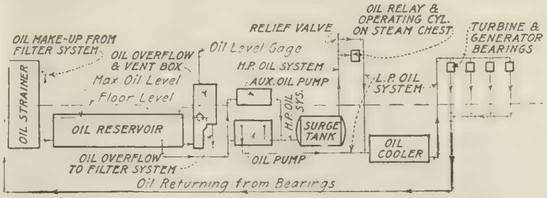


FIG. 5. DIAGRAM OF THE OILING SYSTEM

Filter capacity 1500 gal. per hr.; normal circulation of oil through each bearing of main turbine, in gal. per min.: high-pressure, 10; low-pressure, 12.5; thrust bearing, 20. Total oil-cooler surface, 1200 sq.ft. Hotwell water used to cool the oil. Unit load on bearings, lb. per sq.in.: High-pressure, 80; low-pressure, 124.

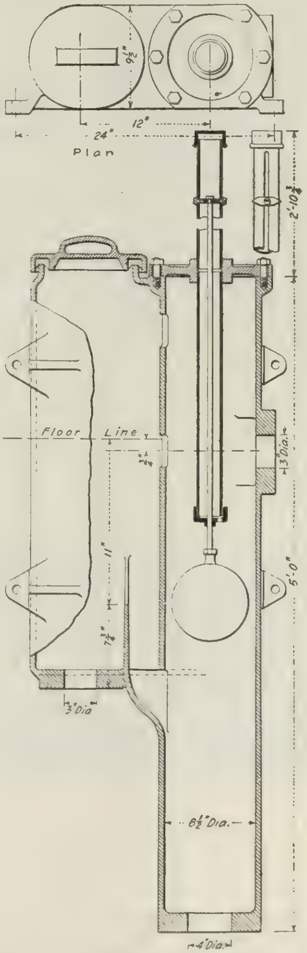


FIG. 6. ASSEMBLY SECTION, OIL OVERFLOW AND VENT BOX

Indicates the amount of oil in the system and provides automatic means of discharging from the system oil taken from the bottom of the reservoir equal in quantity to fresh oil added, making possible continuous operation of turbine on partial filtration system.

the low-pressure turbines, the turbine will quickly increase in speed approximately 3 to 5 per cent., at which point the governor will close the automatic butterfly valve in the low-pressure steam-supply line. The turbine will then slow down until a speed 2 to 3 per cent. below normal is reached, at which point the governor will open the high-pressure inlet valve and admit sufficient high-pressure steam direct from the boilers to keep the turbine operating at that speed. As soon as the trouble is remedied, the switchboard operator, by means of the electric speed changer, can bring the turbine up to normal speed, synchronize it and close the circuit-breaker. The operating engineer must, however, manually close the gate valve in the receiver line, open and reset the automatic butterfly valve and then open the gate valve to put load on the turbine. If the circuit-breaker on the high-pressure opens, it will increase in speed approximately 2 per cent. and remain there under control of its governor. The two low-pressure turbines, being deprived of steam, will cease to carry load. The speed and frequency will therefore drop approximately 3 to 5 per cent., at which point the high-pressure governor valves on the low-pressure turbines will open, and the low-pressure turbines will carry their full rated load on the high-pressure steam. The switchboard operator can immediately readjust his governors to give normal frequency. As soon as the electrical trouble has been corrected, the high-pressure turbine can be synchronized, its circuit-breaker closed and, by adjustment of the speed changers on the three governors, the whole unit restored to normal operation without any assistance from the operating engineer or the manipulation of any valves.

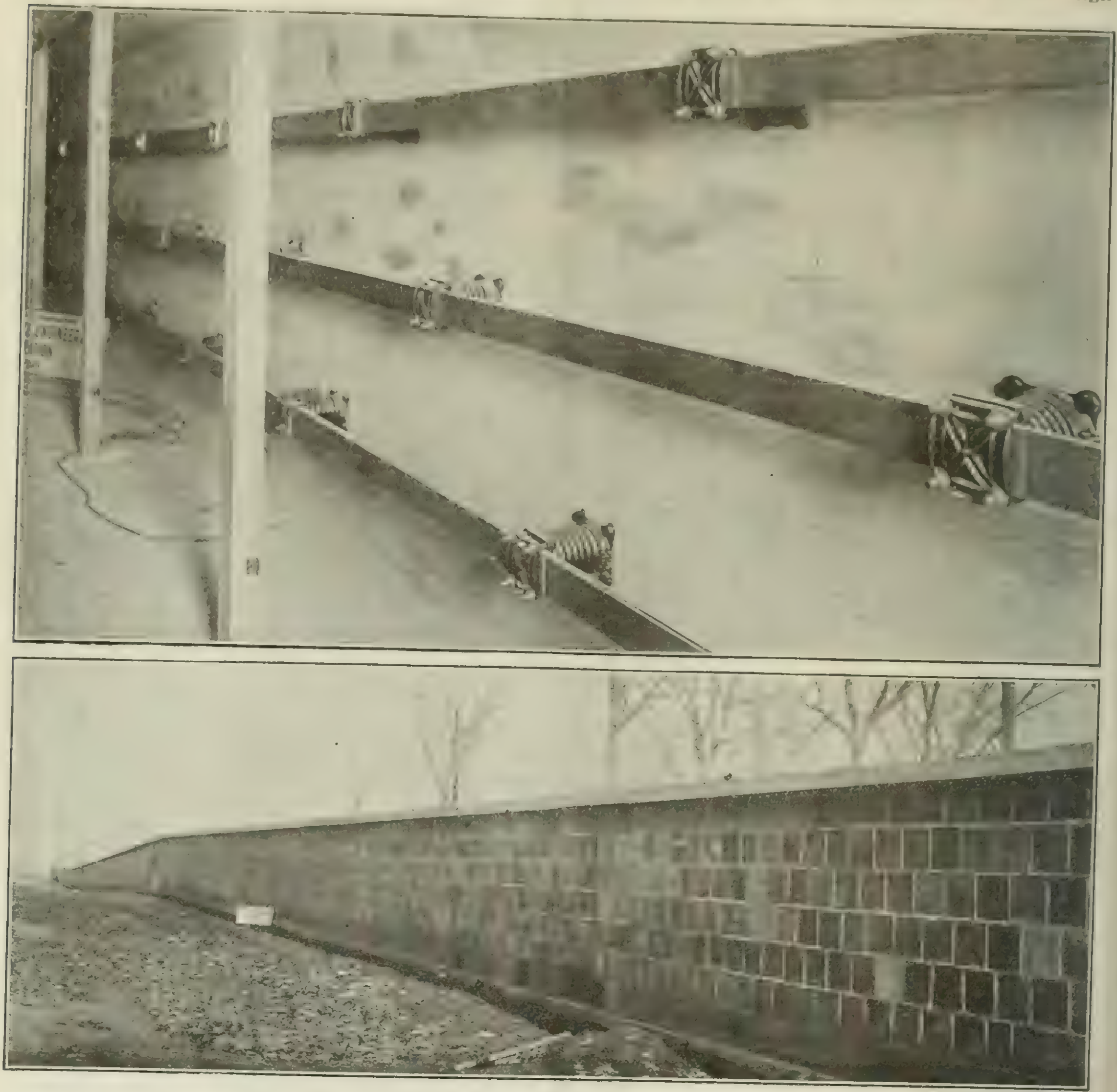


FIG. 7. INTERIOR AND EXTERIOR VIEWS OF THE BUS TUNNEL

Made of tile brick and concrete, 4000 ft. long, current at 12,000 volts is transmitted from the power house to the switch house, where it is distributed. Open transmission line would be too seriously affected by carbide dust from the cyanamid mill.

If the automatic governing mechanism on either low-pressure turbine operates either manually or automatically, the butterfly valve supplying it with steam from the high-pressure turbine and the 14-in. throttle valve supplying it with high-pressure steam will both close, and the circuit-breaker between the generator and its bus section will open, permitting the turbine to come to rest. If the automatic on the high-pressure turbine is tripped, only the two 18-in. high-pressure throttle valves and the main governor-controlled inlet valve will be closed, and the turbine will come to rest. The low-pressure turbines will reduce in speed about 3 to 5 per cent., and then will automatically take high-pressure steam sufficient to carry the load, the governors being quickly adjusted to bring the speed and frequency up to normal.

The automatic signal system keeps the switchboard operator fully informed as to the conditions under which each element is operating and enables him to maintain the proper adjustment of each of the three governors.

The floating lever of each low-pressure governor has a projecting arm which moves across 12 electric contacts closing lamp circuits, the lamps indicating the position of each low-pressure governor. A diagram of these connections is shown in Fig. 1. The operation of these throttles will close these switches and open the main circuit-breaker. But should the circuit-breaker on any one element open, the control system will maintain control of this element and keep the other two elements in service. In the event of injury to one of the three elements and the release of the automatic stop—each element has a safety stop—the circuit-breaker of the particular element will be opened and the element cut out, the other elements remaining in service. The safety stop on each machine is capable of closing its own automatic throttle valve and other steam admissions to that element.

During normal operation the switchboard operator maintains both low-pressure turbine governors in approximately central position. The high-pressure turbine governor is adjusted to fine regulation; but the low-pressure governors are to have not less than three times the speed variation of the high-pressure governor because the governors have three operating conditions, explained a few paragraphs farther on.

This installation is provided with a double set of busses, a sectionalized bus as previously referred to, and also a solid bus. With the sectionalized bus connected to the system, which may already be energized by other units, the circuit-breakers connecting the three generators to the solid bus are closed; the condensing equipment put into operation; steam seals turned on to the low-pressure glands; and a vacuum established on the low-pressure turbines; the auxiliary oil pumps started; the fields of the main generators excited; and either one of the two high-pressure throttles opened sufficiently to start reduction of the high-pressure element. The two low-pressure elements will immediately rotate in synchronism by reason of the field charges. After suitable warming up at slow speed, the unit is gradually brought up to speed and the solid bus synchronized with the sectionalized bus. The three circuit-breakers between the generators and the sectionalized bus are then closed and the breakers between the solid bus and the generators opened. The second high-pressure throttle valve may be opened at any time after the unit has been brought up to normal speed, and before the load exceeds approximately 40,000 kw.

The governors on the two low-pressure elements differ somewhat from that on the high-pressure element, although in mechanical construction the three are almost identical. The high-pressure governor has but one function to perform: that is, to control the opening of the valves admitting steam to the high-pressure turbine. It is therefore arranged to operate throughout its whole travel on a speed variation of approximately 4 per cent.

Each low-pressure governor has its travel divided into three parts and is adjusted to require a 12 per cent. change in speed to operate it over its full range of travel. The lower third of this travel is employed to control the opening of the high-pressure steam valve. The middle third is a neutral zone in which the governor operates idly when all three turbine elements are operating as a combined unit. The upper third is employed to close the butterfly valve controlling the low-pressure steam supply to this element in case its circuit-breaker opens.

The operating conditions are 275 lb. gage steam pressure, 200 deg. superheat and 29 in. vacuum. These figures are higher than those upon which the original guarantee was based, as they were predicated upon 275 lb. gage pressure, 175 deg. F. superheat and 28.5 in. vacuum. For these latter conditions the following performance is guaranteed.

Load in Kilowatts	29-In. Vacuum	28.5 In. Vacuum
	Pounds Steam per Kw.-Hr.	
30,000	11.05	11.55
40,000	10.75	11.15
50,000	10.55	10.90
60,000	10.75	11.10
When operating the high- and one low-pressure side:		
30,000	12.1	12.45
When operating one low-pressure element or high-pressure steam:		
20,000	14.0	14.45

Should the steam pressure be increased at the throttle to 300 lb. abs. (285 lb. gage) with 185 deg. F. superheat, the performance guarantees will be reduced 1.2 per cent.; increasing the pressure to 315 lb. abs. (300 lb. gage) with 185 deg. F. superheat, the guarantees will be reduced $1\frac{3}{4}$ per cent.

The peripheral speed of the last row of blades in each low-pressure element is 513 ft. per sec. mean, 555 ft. per sec. tip.

Excitation for the high-pressure generator is furnished by a 90-kw. generator and for the low-pressure machines by a 115-kw. generator; the voltage for each is 240.

Four 25,000-sq.ft. condensers, each having 5285 one-inch Muntz metal tubes 18 ft. $3\frac{3}{8}$ in. long, are used. The steam-inlet openings of the condensers are 30.5 ft. below the exhaust openings of the turbines. Particulars relative to these condensers, their supports, pumps, intakes, etc., are treated of in another article following this one.

There are four 44,000 gal. per min. circulating pumps, four dry vacuum pumps, four condensate pumps, water pump for cooling the oil, and three blowers for cooling the generators. The above include spares.

A table giving all the important weights, dimensions, speeds, pressures, areas, volumes, loads, velocities and capacities relative to the turbine and condensers—the whole station, in fact—appeared in the first article dealing with this station published in *Power*, Mar. 25, 1919.

For furnishing current for auxiliaries and other uses in the station two 2000-kw. pure-reaction single-flow turbines have been installed; the high-pressure ends of the cylinders are of cast steel. These machines are each of 2500 kv.-a. at 80 per cent. power factor, 60 cycle three-phase 2300 volt. They will operate at 275 lb. pressure, 175 deg. F. superheat, noncondensing, against a back pressure of 5 lb. gage. Their over-all length is 24 ft. 5 in., width 9 ft. 10 in., height 6 ft. 10 in.; the total weight is 81,000 lb., the heaviest piece for the crane being 9000 lb.

Their performance (80 per cent. power factor) is as follows:

Load, Kw.	Water Rate per Kw Hr
1,200	28.1
1,600	25.5
2,000	26.6

One air washer with a capacity of 8000 cu.ft. per min. is provided for each machine, the washers each being driven by a 5-hp. motor and having a pumping capacity of 60 gal. per min.

To obtain high thermal efficiency of the station the noncondensing house turbines drive all auxiliaries, which are motor-driven (except the boiler feed pumps), the amount of exhaust steam used for heating feedwater being regulated to suit station load conditions.

Heat balance studies of the station form the subject of another article which will appear in an early issue.

Fig. 7 shows an interior and exterior view of the bus tunnel used to contain the copper transmission busses connecting the power station with the switchhouse 4000 ft. away. An open transmission system would be too seriously affected by the carbide dust and lime dust.

Boiler Explosion at Paso Robles, California

By P. HANSEN

A HORIZONTAL return-tubular boiler but two years old and tested when new to a pressure of 187 lb. exploded recently at the Natural Soda Products Co. at Keeler on Owens Lake, Calif. The boiler was 18 ft. long and about 6 ft. in diameter. Oil was used for fuel. The usual pressure carried was 100 to 115 lb. The safety valve was set to blow off at 123 lb. pressure and operated with a blowdown to about 110 pounds.

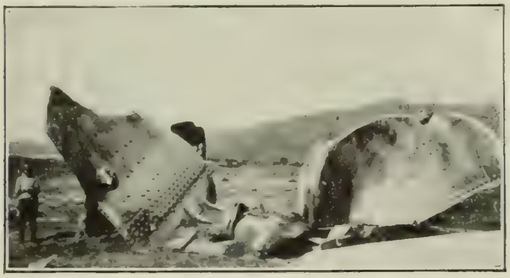


FIG. 1. SHOWING THE REAR PLATE AND END OF THE BOILER

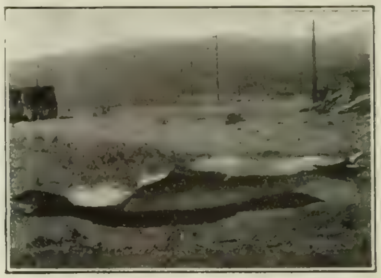


FIG. 2. CENTER PLATE AFTER 490-FT. FLIGHT

FIG. 3. ANOTHER VIEW OF FIG. 1

Steam was used for heating water in the carbonating tanks, blowing out clogged valves, etc. The quantity used was very irregular; for an hour or more at times practically none was required, and then again all the steam that the boiler could possibly produce was used. The boiler was operated 24 hours a day and 7 days a week. The feed water contained a large amount of inorganic impurities and was fed cold to the boiler. It was the practice to blow some water out twice each twelve-hour shift.

The explosion occurred at 1 a.m. The fireman had come on duty at midnight. He was badly injured and died a few hours later.

The boiler consisted of three plates, each 6 ft. in length. The center one, at a point over the furnace, was torn lengthwise of the boiler. The plate was also torn away from the rest of the boiler, straightened out and thrown a distance of 490 ft. At some parts the

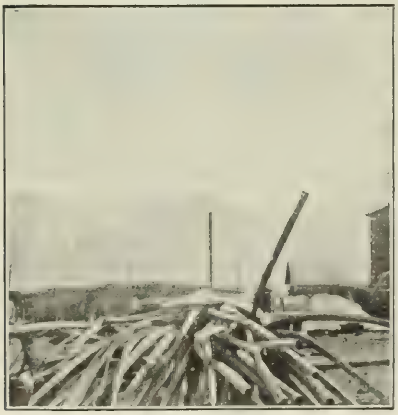


FIG. 4. TUBES AND FRONT HEAD

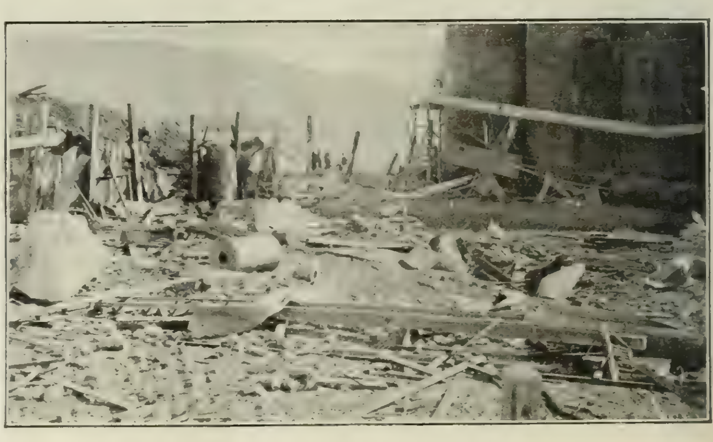


FIG. 5. WHERE THE BOILER HOUSE ONCE STOOD

plate was torn close to the girth seam, elsewhere the tear was in the seam, the rivets being pulled apart. The edges of the plate in the tear which was over the fire were drawn very thin and smooth, showing that the plate had been very hot. After the explosion the hard scale adhering to the plate, about two feet up from the rupture, was fully one-eighth in. thick; the scale farther down and over the furnace had doubtless been much thicker, but it was broken off by the explosions. The explosions were heard with an interval of about one-half minute, the second explosion being the louder.

It is the opinion of some that the scale prevented the water from coming in contact with the boiler plates over the furnace; the plates therefore became overheated and gave way under the high pressure. Another reason may have been that with the plate sagging the scale loosened and the water reaching the overheated plate and suddenly cooling it caused the rupture, and this sudden opening reacted with excessive pressure on all parts of the boiler, tearing it to pieces.

Fig. 1 shows the rear plate and the back end of the boiler with stays, etc.; this was thrown 470 ft. This plate was also torn at the bottom with sharp edges similar to those that were found on the center plate. All other tears have rough edges, showing the grain of the steel. Fig. 2 shows the center plate as it lay after its flight of 490 ft.

Fig. 3 is another view of the head and plate shown in Fig. 1, but from a different point and shows the head and braces. The front plate and head with all the tubes were blown 150 ft. and are shown in Fig. 4. The boiler house stood three feet behind the coke pile shown in the background.

Fig. 5 shows the ground occupied by the boiler house. The brickwork in the center marks the remains of the boiler setting. The building was about 26 ft. long, 24 ft. wide, 25 ft. high and was built of heavy timbers and corrugated iron. Fortunately, the force of the explosion was away from the main plant, otherwise there might have been considerable loss of life and much more damage to the plant. The timbers of the boiler house were smashed to matchwood and scattered over a wide area. Bricks were thrown about 600 ft. in all directions, going through the roofs of buildings, etc. Luckily very few men were at work that night, and excepting the fireman but one man was injured.

The Electrical Study Course—Fundamental Principle of Three-Wire Generators

Gives a brief description of the actual connections of a three-wire generator and its accesories, and then goes on to a discussion of the fundamentals underlying the theory of operation, in preparation for a more extended description.

BALANCER sets are the most convenient means of providing a three-wire system where a source of voltage for the outside wires is available from a separate service or when the unbalanced current required for the system is small. However, there are conditions where it is preferable to use a so-called three-wire generator. This type of machine has come to supplant the combination of two generators in series that was originally used in three-wire installations.

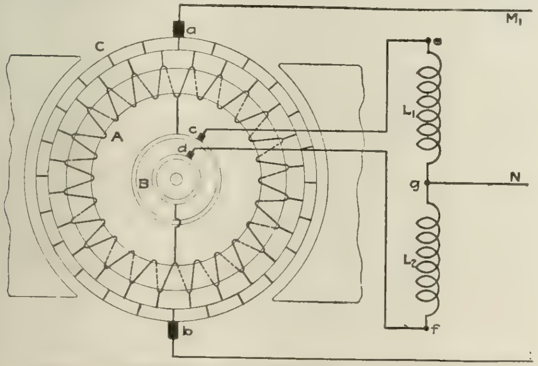


FIG. 1. SCHEMATIC DIAGRAM OF THREE-WIRE GENERATOR

The three-wire generator is an ordinary direct-current generator, excepting that in addition to having a commutator its armature is also provided with slip rings that are connected to the armature winding in the same manner as would be those of an alternating-current generator. The connections between the windings, commutator and the slip rings and the connections of the machine to a three-wire system may be represented as in Fig. 1. The armature winding is represented by A, the commutator by C, and the slip rings by B. The brushes a b on the commutator are connected to the outside wires M_1 and M_2 of the three-wire system, and the brushes c d on the slip rings are connected to the ends e f of two equal inductances L_1 and L_2 connected in series. The mid-point g of these inductances is connected to the neutral N of the three-wire system. This diagram is rather involved, therefore we shall not attempt to base the explanation on it, but use the simpler diagrams, Figs. 2 and 3. Such a treatment will also give us an opportunity of investigating what inductances are and the reason for their application in the present case.

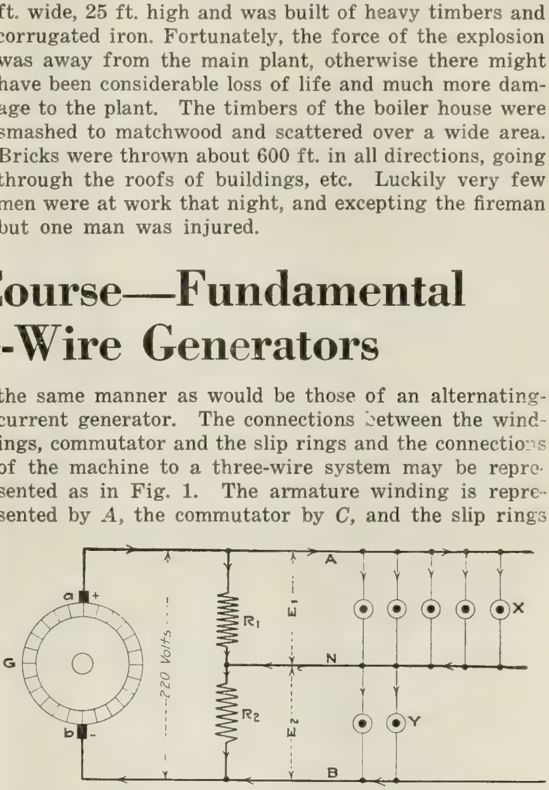


FIG. 2. THREE-WIRE SYSTEM WITH UNBALANCED LOAD

First of all, suppose we have a system such as that represented in Fig. 2. It will be seen that it is like that of a three-wire system using a balancer set except for the fact that the balancer machines have been supplanted by the resistances R_1 and R_2. Assume that G is a 220-volt generator and the resistance of R_1 and R_2 is equal but of very low value, for example, 0.1 ohm. Consider what the voltages E_1 and E_2 across A N and

N B, respectively, will be for various conditions of loading represented by the groups of lamps X and Y. Supposing that the lamps used have each a resistance of 100 ohms, what would be the value of E_1 and of E_2 if there were five lamps lighted at X and two at Y?

The joint resistance R_X of the five lamps in group X is equal to the resistance of one lamp divided by the number of lamps, or in this case $R_X = \frac{100}{5} = 20$ ohms. The joint resistance R_Y of group Y is $R_Y = \frac{100}{2} = 50$ ohms. Let R_A equal the joint resistance of the group of lamps X and the resistance R_1 then $R_A = \frac{1}{\frac{1}{R_1} + \frac{1}{R_X}} = \frac{1}{\frac{1}{0.1} + \frac{1}{20}} = 0.0995$ ohm; that is, the joint resistance of all circuits connected between A and N is equal to 0.0995 ohm. If we let R_B equal the joint resistance of R_2 and lamp group Y, then $R_B = \frac{1}{\frac{1}{R_2} + \frac{1}{R_Y}} = \frac{1}{\frac{1}{0.1} + \frac{1}{50}} = 0.0998$ ohm. Then the total resistance between A and B equals $R = R_A + R_B = 0.0995 + 0.0998 = 0.1993$ ohm, and the total current $I = \frac{E}{R} = \frac{220}{0.1993} = 1103.9$ amperes. Then the volts across A and N are $E_1 = R_A I = 0.0995 \times 1103.9 = 109.8$, and the volts across N and B are $E_2 = R_B I = 0.0998 \times 1103.9 = 110.2$. From this it is seen that the value of E_1 and E_2 is quite close to what they should be in a three-wire system, namely, 110 volts.

Let us take a case where the unbalancing is more serious; for example, one in which there are 100 lamps at X and none at Y, Fig. 3. We now have $R_X = \frac{100}{100} = 1$ ohm and $R_A = \frac{1}{\frac{1}{R_1} + \frac{1}{R_X}} = \frac{1}{\frac{1}{0.1} + \frac{1}{1}} = 0.09091$ ohm. Also since there are no lamps at Y we have $R_B = R_2 = 0.1$ ohm. The total resistance $R = R_A + R_B = 0.09091 + 0.1 = 0.19091$ ohm. Then $I = \frac{E}{R} = \frac{220}{0.19091} = 1152.4$ amperes, which gives $E_1 = R_A I = 0.09091 \times 1152.4 = 104.76$ volts and $E_2 = R_B I = 0.1 \times 1152.37 = 115.24$ volts.

In this case the voltages E_1 and E_2 are about five volts lower and higher than they should be, but even that difference is not very serious. It will be found that it is only when the difference between the number of lamps across X and Y is great that the discrepancy in the voltages E_1 and E_2 becomes objectionable. That is, if the resistance of X is low—as it will be if it contains many lamps in multiple—as compared to Y, then E_1 will be considerably lower than E_2. Just how much lower depends upon the resistance of R_1 and R_2. If these are very low, the difference will not be very great, but the nearer the value of R_1 and R_2 approaches that of X or Y the greater will be the difference between E_1 and E_2. It should be understood that when the number of lamps in Y exceeds that in X the same reasoning holds true except that E_2 will in that case be the lower voltage.

From the foregoing it is evident that Fig. 2 really represents a three-wire system where the resistance of R_1 and R_2 is low as compared with that of the load on the system. Such an arrangement would, however, never be used, since it would be enormously wasteful of energy. The current through R_1 and R_2 alone, without any lamps being turned on, would be equal to $\frac{220}{R_1 + R_2} = \frac{220}{0.1 + 0.1} = 1100$ amperes, which is of course prohibitive. If, however, some means could be devised by which R_1 and R_2 would throttle down the current that the generator G tries to send through them and yet provide a path of low resistance for any unbalanced current that might tend to flow from N through R_1 or R_2 to A or B respectively, it would be possible to use it in place of a balancer set.

Considering again the conditions in Fig. 3, the current through R_1 is $I_1 = \frac{E_1}{R_1} = \frac{104.76}{0.1} = 1047.6$ amperes and the current in R_2 is $I_2 = \frac{E_2}{R_2} = \frac{115.24}{0.1} = 1152.4$ amperes.

The difference between the current through R_2 and R_1 is $1152.4 - 1047.6 = 104.8$ amperes, which is the value of the current in the neutral. That is, R_2 carries the unbalanced current, which is, however, only a small part of the current that it takes itself. Consequently, if we could throttle the latter without impeding the former, we would, as before stated, have the same result as with a balancer set.

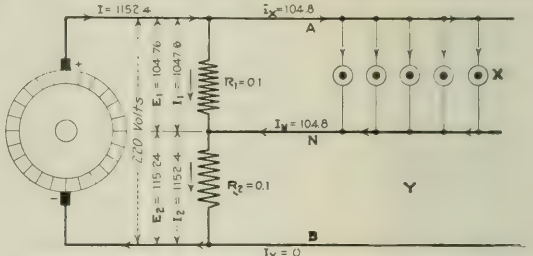


FIG. 3. THREE-WIRE SYSTEM LOADED ON ONE SIDE ONLY

By using inductances such as L_1 and L_2 in Fig. 1 in place of the resistances R_1 and R_2 as in Fig. 2 and by connecting the inductances to the brushes c d instead of to a b as the resistances are connected, we are able to accomplish the apparently impossible proposal of limiting one current while allowing free passage to the other. The explanation of this method will follow in the subsequent lessons.

In the preceding problem it was stated that a 220-volt generator rated at 455 amperes was used to supply current to a 110- to 220-volt system. It was required to find how many 40-watt lamps could be operated on the system under these conditions. Since the generator is rated at 220 volts and 455 amperes, its capacity is $220 \times 455 = 100{,}100$ watts. If each lamp takes 40 watts, the number of lamps that can be operated will be $\frac{100{,}100}{40} = 2502$. It was further required to determine the number of lamps that could be operated if the system had to carry a motor load amounting to 60 hp. The motor load in horsepower multiplied by 746 would be its equivalent in watts, or power required for motors equals $60 \times 746 = 44{,}760$ watts. This subtracted from the generator capacity would give the amount of power available for lighting, or power for lamps equals 100,100 — 44,760 = 55,340 watts. The number of 40-watt lamps that could be used would therefore be $\frac{55,340}{40} = 1384$. In addition to the foregoing it was also required to determine the size of the neutral wire required in the latter case. Assuming that the system might be entirely unbalanced, we know that the neutral wire must be capable of carrying as much current as the outside wires. The current in the outside wires is that required by the lamps connected between them and the neutral, and the number of lamps on each side is half the total number on the system. In the present example the total number is 1384, hence the number of lamps on each side of the system is $1384 \times \frac{1}{2} = 692$. Each of these takes 40 watts at 110 volts, making the maximum load per side $40 \times 692 = 27,680$ watts, which, divided by the voltage, gives the current for each outside wire, namely, $\frac{27,680}{110} = 252$ amperes. Since the neutral is to be of a capacity to carry the current taken by the lamps on one side of the line, it must be large enough to take care of 252 amperes. From the table of carrying capacity of wires we find that if rubber-covered wire is to be used, the size conductor required is 300,000 circular mils and that if the other insulation is used the wire must be No. 000.

In Fig. 2 if there are 50 lamps across *X* and 30 across *Y* and each has a resistance of 150 ohms, and the rheostats R_1 and R_2 each has a resistance of 0.5 ohm, what will be the values of E_1 and E_2? What capacity would the generator *G* have to be to carry such a load?

Test of Liberty Engine

Some remarkably interesting results were obtained in a heat-balance test on a standard high-compression Army-type engine as recently conducted at McCook's Field, Dayton, Ohio. During the test the engine was run at a constant speed of 1600 r.p.m., with the throttle wide open. The average horsepower developed under these conditions was 372.5. The conditions throughout the test were maintained constant and the length of the test was one hour.

The gasoline used had a gravity of 68 deg. Baumé and the average consumption of fuel was 0.492 lb. per hp.-hr. The amount of jacket water pumped was 90 gal. per min., the inlet and outlet temperatures being 150 deg. and 170 deg. F. respectively.

Taking the heat value of the fuel as 19,000 B.t.u. per lb. and assuming 100 per cent. efficiency of the engine, the 183 lb. of gasoline per hour required to produce the average horsepower developed would theoretically have produced 1365 hp. From the results of the test this power was distributed as shown in the acompanying table. The table indicates that 27.3 per cent. of the theoretical horsepower was transformed into useful power for the engine, and that 3.5 per cent. was lost in friction. The loss of heat through the exhaust gases was 44.4 per cent., which is unusually high, while the heat absorbed by the jacket water is lower than usual, being only 24.8 per cent.

HEAT BALANCE OF STANDARD TWELVE-CYLINDER LIBERTY ENGINE

	Horsepower	Per Cent. of Brake Horsepower	Per Cent. of Total
Average brake horsepower	372	100	27.3
Average heat absorbed by jacket water	339	91	24.8
Average friction horsepower	48	13	3.5
Carried off by exhaust gases	606	..	44.4
Total	1,365		100.0

The Value of Yard Screenings

By W. H. Wakeman

The following figures are the results of a test made with a return-tubular boiler to determine the value of yard screenings of anthracite mixed with a small proportion of bituminous coal:

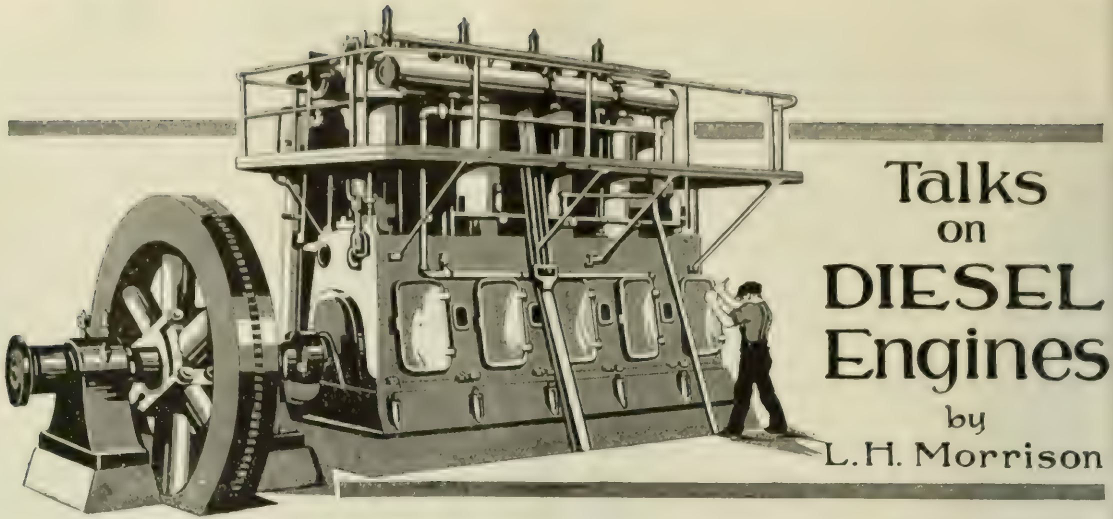
Diameter of shell, in	66
Length of shell, ft	15
Number of tubes	96
Diameter of tubes, in	3
Length of tubes, ft	15
Total length of tubes, ft	1,440
Heating surface in one-half of shell, sq.ft	129
Heating surface in tubes, sq.ft. (1440 ÷ 1.37)	1,051
Heating surface in one head, sq.ft	26
Total heating surface, sq.ft	1,206
Nominal horsepower	100
Grate surface, sq.ft. (5½ x 5½)	30.20
Ratio of grate to heating surface	1 to 40
Grate ⅜-in. air space, ⅜-in. iron.	
Estimated air space, per cent	40
Balanced draft supplied by blower.	
Steam supplied through ⅜-in. steam pipe.	
Power used to operate blower, hp	3
Draft observed from 0.18 to 0.4 inch of water.	
Latest improved type of draft gage.	
Duration of test, hours	16
Steam pressure, lb	75
Temperature of feedwater, deg. F	200
Quality of steam	Dry
Yard screenings, lb	6,210
Bituminous coal, lb	1,555
Total, lb	7,765
Less 4 per cent. moisture, lb	310
Net weight, lb	7,455
Proportion	4 to 1
Coal per hour, lb	466
Coal per hour, sq.ft. grate surface per hour, lb	15.4
Coal per horsepower-hour, lb	3.67
Weight of ash and unburned coal, lb	1,559
Weight of combustible, lb	5,896
Proportion, per cent	21
Water by meter, cu.ft	1,061
Plus 2 per cent., cu.ft	21
Weight per cubic foot (203 deg.), lb	60
Total weight, lb	64,920
Water evaporated per pound of dry coal, lb	8.71
Water evaporated per pound of combustible, lb	11
Water evaporated per hour, 16 hours, lb	4,058
Water per horsepower, lb	32
Power developed for 16 hours, hp	126.8
Water evaporated in 15 hours, lb	63,342
Water evaparated per hour, lb	4,223
Power developed for 15 hours, hp	132

The bituminous coal was screened and nothing larger than about ⅜ in. was used. Care was taken to mix it thoroughly with the screenings. It was well wet down before using. This mixture of coal cost $5 per gross ton, whereas bituminous coal was $10 per gross ton at the time of the test.

The water meter was calibrated by running 5 cu.ft. through it into a barrel. Temperature 200 deg. F. Weight per cubic foot, 60 lb. The meter was adjusted until 5 cu.ft. weighed 293 lb., therefore the meter was 2 per cent. light.

It will be noticed that the water evaporated in 16 hours is 4058 lb. per hour and the amount evaporated in 15 hours is 4223 lb. per hour, also that the power developed in 16 hours was 126.8 hp. as compared with 132 hp. for 15 hours. The following explanation will make this apparent discrepancy in coal consumption and boiler horsepower developed plain.

During the test readings of the meter were taken every hour approximately. These readings showed a considerable variation in the power developed. At the end of 15 hours the boiler had averaged 132 hp. There was a considerable heat in the furnace at that time, more than there was at the beginning of the test. In order to utilize this heat and make a fair test, the fire was allowed to burn for another hour, thus raising the evaporation per pound of coal burned, although there was no way of telling how much coal was burned during the last hour, therefore only the average per hour could be given. Of course the power developed during the last hour fell off sharply, thus lowering the average from 132 hp. for 15 hours, to 126.8 hp. for the 16-hour run.



Talks on DIESEL Engines

by

L. H. Morrison

XII—After a day of trouble with the fuel pump, the chief's talk naturally turns to the construction of fuel pumps and their operation.

THE DAY had been full of bad luck and hard work at the Diesel plant, and so the chief was rather surprised when all the day force showed up for the night's meeting.

"Our talk tonight will be pretty pat, after the trouble we had today with the fuel pump," he remarked.

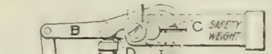


FIG. 1. FUEL PUMP OF AMERICAN DIESEL ENGINE

The men smiled significantly, for the trouble had been a poser for Egan, with all his years of experience.

"There are two classes of fuel-injection pumps for Diesels," he began. "In one the amount of fuel injected is regulated by controlling the closing of the suction valve of the pump. In the other the stroke of the pump is changed to alter the fuel charge."

A puzzled frown had appeared on Woods' face as the chief proceeded. Now he spoke up.

"But it seems to me I've seen a sort of bypass arrangement to govern the fuel charge."

"You're right," smiled Egan. "My classification was a bit narrow, perhaps. Some makers bypass a part of the oil to regulate the amount of the charge and others use a hollow plunger with a sleeve cutoff valve; but both are simply variations of the controlled suction valve type.

"Since you all were broken in on the old American Diesel, we'll take up its fuel pump first. Fig. 1 shows a cross-section of the pump. The pump plunger is driven by the eccentric, which also gives motion through the rod *A* to the lever *B*. This lever is fulcrumed on the eccentric *C*, which may be turned by the rise or fall of the governor balls. The turning of the eccentric *C* alters the height of the roller *D* that bears against the suction-valve stem and so determines the point at which the suction valve will close when the lever *A* is moving upward. This upward move-

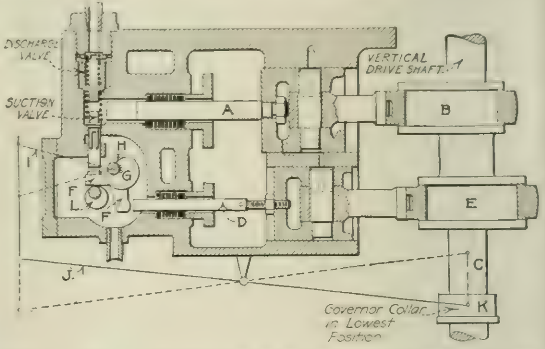


FIG. 2. FUEL PUMP OF BUSCH-SULZER DIESEL ENGINE

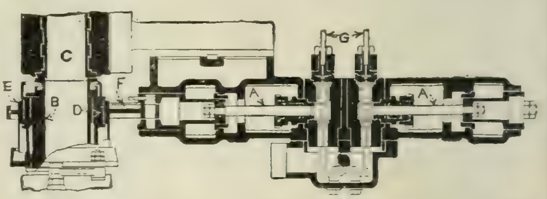


FIG. 3. FUEL PUMP OF McINTOSH & SEYMOUR DIESEL ENGINE

In the next article the chief will talk about governors and governor troubles after announcing the cheering news of an increase of pay.

ment is made on the discharge stroke of the pump plunger.

"This pump is not positively geared to the crankshaft of the engine, but between the pump and the engine is a clutch pinion that allows the pump to be operated by hand in starting. The disadvantage is that the pump may be stopped at the wrong point. It should always be in such a position that the plunger delivers oil when the piston is on its suction stroke. This gives the fuel time to reach the atomizer before injection begins.

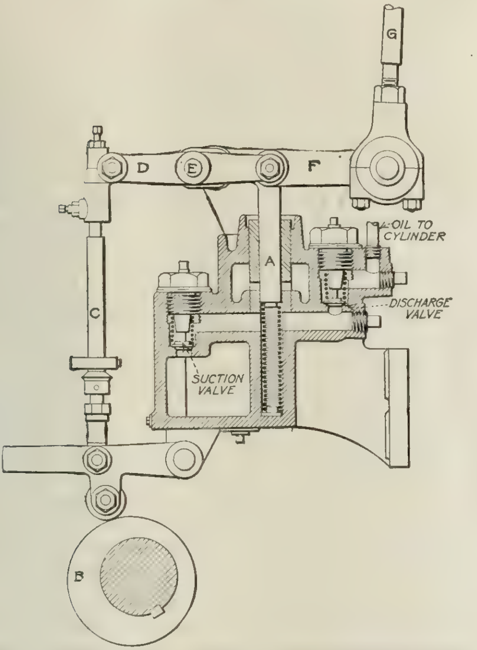


FIG. 4. FUEL PUMP OF ALLIS-CHALMERS DIESEL ENGINE

"The discharge valves are ball valves and the smallest particle under the ball will cause it to leak. If a leak occurs, ream the valve seat very carefully and put in a new ball. In regrinding the suction valve only the slightest pressure should be put on the stem. In using this pump you may find the discharge valve leaking even when the seat is perfect. This is due to the lag of the valve. If the valve guard allows it to lift more than $\frac{1}{16}$ in., the valve cannot return quick enough to cut off the oil flow. When using distillate oil, a spring placed over the ball will increase the closing speed and decrease the leaking.

"Another point that often puzzles the operator is the leaking that shows up on a change of oil, especially from a heavy to a light oil. It does not require a very good valve to seal when a heavy oil is used; but as soon as distillate is substituted it is impossible to operate without regrinding the valves.

"The links that move the suction valve are adjustable. To equalize the fuel charges delivered by the several pumps to their respective cylinders, block up the governor to its highest point and turn the pumps by hand, and see that the suction-valve stems are depressed equal amounts. Then, with the governor in its lowest position see that the clearances between the stems and the rollers are the same—this should be 1/100 in. To prevent the governor from hunting, the suction valve should open when the pump plunger is at the middle of its suction stroke, and the suction valve should close when the plunger is at its midposition on the delivery stroke. This is when the governor is blocked to its full-load position.

"A sectional view of the pump used on the Busch-Sulzer engine is shown in Fig. 2. The fuel plunger *A* is driven by an eccentric *B* on the vertical shaft *C*, which is driven by the crankshaft and gives motion to the camshaft. The plunger *D* is driven by the eccentric *E* on the shaft *C* and opens the suction valve through the bell-crank *F* carried by the eccentric *G* on the shaft *H*. The shaft *H* is connected by levers *I* and *J* to a collar *K* that is under control of the governor.

"The plunger *A* is timed to discharge oil into the needle-valve cage when the engine piston is on the suction stroke. The plunger *D* is arranged to open the suction valve when the plunger *A* is at about midposition on its suction stroke and to close the suction valve when the plunger *A* is at about midposition on its discharge stroke, with the engine under full load.

"If the engine speeds up, the governor moves the collar *K* upward, and, as shown by the dotted positions of the levers *I* and *J*, turns the shaft *H* and swings the eccentric *G* to a higher position. As a result, the bell-crank lever *F* strikes the suction-valve stem sooner and gives earlier opening of this valve. When the engine is to be stopped, the cam *L* is turned until it forces the suction valve off its seat and holds it there during the whole discharge stroke. To fill the fuel line, preparatory to starting, a further movement of the cam causes the dog to raise both the suction and the discharge valve.

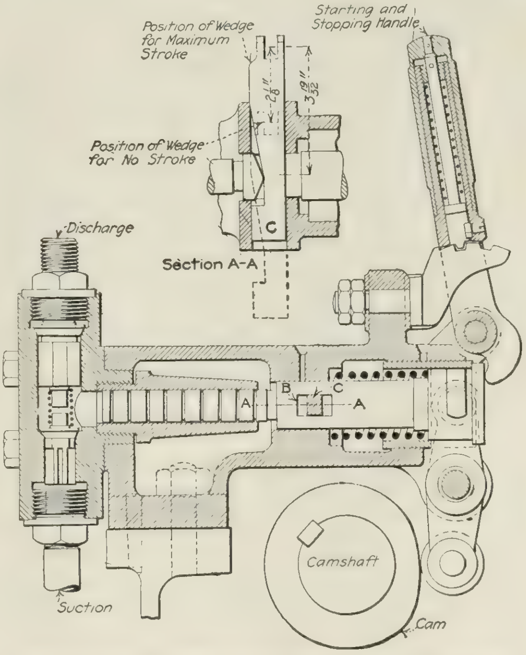

Position of Wedge for Maximum Stroke
Starting and Stopping Handle
2 1/8"
3 19/32"
Position of Wedge for No Stroke
C
Discharge
Section A-A
B
C
A
A
Camshaft
Suction
Cam

FIG. 5. FUEL PUMP OF McEWEN DIESEL ENGINE

"This pump probably regulates closer than any other type. The governor has no great frictional resistance to overcome, and so its smallest movement is communicated to the pump.

"In this pump there are but three things that cause trouble. The first is the plunger packing. It's important that the plungers be carefully packed to prevent leaking; nevertheless don't put too much pressure on the packing or the plunger will score. The second is the suction valve. This valve will leak if gritty oil is used, and if the oil carries much sulphur, pitting on the valve faces will occur. The third source of trouble is the discharge valve. Its springs often break and the valve itself will not seat quick enough to keep the oil from flowing back. In making up valve springs I've found it is best to anneal the spring wire before winding it to size and then harden it. In this way you don't get the surface fractures that will occur when the spring is wound without annealing."

"Chief, how often ought the pump valves to be ground?" Woods inquired, seeing that Egan was about ready to take up another pump.

"That depends on the kind of fuel oil. With ordinary Diesel engine oil that has been filtered, I should say once every three months. With a heavy grade of oil, such as we receive at times, you'll find them cut bad enough to warrant regrinding in thirty days.

"There's one other little kink," Egan continued, "that you mustn't forget. Each time the suction valve is ground, the valve is lowered and this lowering will cause the bell-crank lever to strike the stem earlier in the stroke and hold the valve open longer. The consequence is that this particular engine cylinder will not carry its proper share of the load.

"The McIntosh & Seymour engine uses a variable-stroke type of fuel pump, and Fig. 3 shows a section of it. There are two outside-packed plungers *A* that move in unison and that are given a reciprocating motion by the eccentric *B* keyed to the shaft *C*. A second eccentric *D* fits over the eccentric *B* and is connected by links to the governor on the upper end of the shaft *C*. Thus, with a variation in speed, the governor rotates the outer eccentric *D* somewhat and so alters the stroke of the pump plungers, since they are driven by a strap *E* on the eccentric *D* and an eccentric rod *F*. The oil is discharged through the pipes *G* to the engine cylinders. As the pump stroke is changed, the amount of the fuel charge is correspondingly altered. This pump needs little attention beyond an occasional repacking of the stuffing-boxes and regrinding of the valves."

"Mr. Egan," Woods interjected, "you say that the pump doesn't govern the fuel charge by opening the suction valves *H*. If that's the case, what's the use of the cam and those two levers above the suction valves?"

"They're used when the engine is stopped," explained the chief. "The cam is turned, forcing the suction valves open, and so no oil is pumped. A further movement of the cam raises the suction valves higher still and holds the discharge valves open. This is the position when the fuel lines are filled prior to starting.

"The pump used by the Allis-Chalmers Co. also regulates the amount of fuel delivered to the engine by changing the length of stroke of the plunger. Fig. 4 shows a cross-section of the pump. The plunger *A* is given a reciprocating motion by the action of the eccentric *B* through the drive rod *C* and the lever *D*. The lever *D* is fulcrumed on a pin *E* carried by the short arm of a bell-crank lever *F*, the long arm of which is connected to the governor mechanism by the rod *G*. If the speed of the engine decreases, the rod *G* is drawn upward, causing the pin *E* to be lowered. The rod *C* then receives an increased lift from the cam and the pump plunger makes a longer stroke, delivering more oil."

Woods broke into Egan's discourse.

"It looks to me as if there would be a big load on the governor when the plunger began to pump the oil."

"So there would, my boy, if the pump was handling the oil against a high pressure; but in the Allis-Chalmers engine an open nozzle is used. Oil is delivered during the suction stroke of the engine, and so there is only the friction of the oil in the fuel line to be overcome.

"To keep this pump in condition a little regrinding and attention to the fulcrum pins is required. Among engineers there is a tendency to allow pins to wear badly before renewing. You can see that a small amount of wear would affect the governing. Don't be afraid to true up worn pins or to ream the bearings and insert new brass bushings.

"The next illustration, Fig. 5, is a cross-section of the pump used on the McEwen engine. This pump regulates by the governor altering the length of the suction stroke of the pump plunger. As shown in the section *AA*, the plunger has a slot *B* in which is a wedge *C* under control of the governor. A movement of the sleeve causes the wedge to move, increasing or decreasing the length of the suction stroke of the pump, and so altering the fuel charge. No packing is used, dependence being placed on the oil sealing the plunger. Since the nozzle used is an open one, the discharge pressure is negligible. The oil seal usually is found satisfactory. If you ever run an engine having this type of pump and have to renew the plunger spring, make it of larger size wire. It will make the plunger snappier in action. The Snow engine employs a pump with a wedge adjustment quite like this one.

"Outside of the little details that require attention on all pumps, you can say that the fuel pump is about the least troublesome of all the Diesel-engine parts. Of course, when you use heavy, tarry or dirty oil, the valve of any make of pump will cause trouble, but that happens only when a good filter is not used. However, we'll talk of filters another time."

Unnecessary engine friction can be overcome by thoroughly lubricating the valve seats and walls of the cylinder, but no hard and fast rule can be given regarding the amount of oil to be fed to steam engines. It is necessary to take into consideration the kind of valves, whether rotative or slide valves, balanced or not; the speed of the engine, whether high or low; whether low-pressure and moist steam, or high-pressure and comparatively dry steam is being used.

As soon as steam leaves a boiler, the tendency is to condense or to return to water, due to the radiation of heat. A bare pipe containing steam, when exposed to still air will condense less steam than when the pipe is exposed to air in motion.

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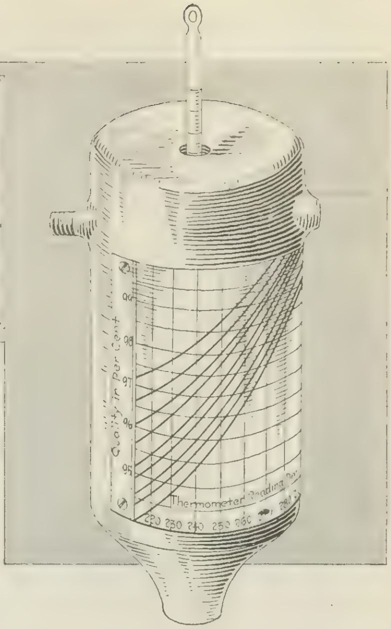
An Improved Form of THROTTLING CALORIMETER

By

*W. R. Woolrich**



When using the throttling calorimeter, the data of the test are substituted in a formula or are used in connection with a curve sheet to find the quality of the steam. This article explains how the instrument may be made self-contained by having the necessary curves drawn on a metal plate fastened to the barrel of the calorimeter. Thus, having observed the initial pressure of the steam and the temperature in the calorimeter, the quality can at once be found from the curves on the plate.

ENGINEERS know very well that the steam furnished by the average boiler is not dry saturated steam, but that it contains more or less moisture. Then, 100 minus the percentage of this moisture, by weight, is called the quality of the steam, and a common way of finding the quality is by the use of the instrument called the throttling calorimeter, one form of which is shown in section in Fig. 1.

The steam to be tested flows from the steam main through the sampling pipe *A* and the valve *B* and then passes through the small throttling orifice *C*, escaping into the interior of the barrel *D* of the calorimeter. From this chamber it flows out into the open air by way of the exhaust opening *E* at the bottom. The U-gage *F* is connected to the interior of the calorimeter by the pipe *G* and is used to measure the slight pressure existing inside. A thermometer *H* is inserted in a well extending down into, and is used to find the temperature of the steam in the calorimeter.

In making an accurate test for the quality of steam, the pressure of the steam in the main is observed, the temperature of the steam in the calorimeter is read from the thermometer, and the pressure inside the calorimeter, above the pressure of the atmosphere, is read from the U-gage in inches of mercury. Then, by the use of a somewhat lengthy formula,[1] the quality of the steam may be calculated.

The use of the U-gage, while desirable in extremely accurate performance tests, is not necessary for ordinary work. All that it does is to make correction for the slight pressure existing inside the calorimeter, above atmospheric pressure, and this correction does not affect the quality of the steam by more than a few hundredths of one per cent. The operating engineer is justified in omitting this correction, therefore, and by so doing he simplifies the matter of finding the quality of the steam.

Neglecting the U-gage reading simply means that the pressure inside the calorimeter is assumed to be equal to that of the atmosphere, or 14.7 per sq.in. Under these conditions, the quality of the steam may be found by the formula[2]

$$X = \frac{1050.8 + 0.476\,T - h}{l}$$

in which the various letters have the meanings given in the first footnote. Thus, for any given test, *T* becomes the temperature indicated by the thermometer in the calorimeter and *h* and *l* the heat of the liquid and the latent heat at the absolute pressure in the steam main, as found from the steam tables.

The trouble with this method, however, is that it requires the finding of certain values from the steam tables and then a number of calculations as indicated by the formula. As a result, technically trained men are practically the only ones that use it. Few operating engineers have mastered the use of the throttling calorimeter for finding the quality of steam. This statement is no reflection on stationary engineers, but rather emphasizes the failure of the makers of calorimeters to put on the market an instrument that required no knowledge of thermodynamics in its operation.

Some calorimeter manufacturers have tried to get around this objection by sending out with their instruments curve sheets from which the quality of the steam can be read off when the steam pressure and the reading of the calorimeter thermometer are known. This is a

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*Assistant professor of mechanical engineering, University of Tennessee.

[1] The formula ordinarily used for finding the quality of steam is:

$$X = \frac{L + H + 0.476\,(T - t) - h}{l}$$

in which
X = Quality of steam;
L = Latent heat of steam at absolute pressure in calorimeter;
H = Heat of liquid at absolute pressure in calorimeter;
T = Temperature indicated by thermometer in calorimeter, in deg. F.;
t = Temperature of dry saturated steam at absolute pressure in calorimeter;
h = Heat of liquid at absolute pressure in steam main;
l = Latent heat of steam at absolute pressure in steam main.

[2] Since the pressure in the calorimeter is taken as 14.7 lb., the values of *L*, *H* and *t* in the formula given in the first footnote are 971.7, 180 and 212, and the formula then becomes $X = \frac{971.7 + 180 + 0.476\,(T - 212) - h}{l}$, which reduces to $X = \frac{1151.7 + 0.476\,T - 100.9 - h}{l}$, or, finally, $X = \frac{1050.8 + 0.476\,T - h}{l}$

step in the right direction, but it requires the curve sheet to be kept at hand to interpret the results from the calorimeter. Now, the operating engineer is only human, and he will always look with disfavor on any device that requires the use of a book or a curve sheet to enable him to interpret the information he has obtained. He will demand an instrument that he can demonstrate to friend or boss without having to apologize for not having the necessary tables or curves with him.

Numerous attempts have been made at the University of Tennessee to train practical operating engineers to use the throttling calorimeter in connection with both tables and curve sheets; but the instrument lacked completeness in that it would not give results by looking at it or studying it alone. It required too much auxiliary information and computation. This obstacle has been overcome by preparing a set of curves to interpret the readings of the calorimeter and mounting these curves directly on the outside of the barrel of the instrument. The simplest way is to make a flat metal plate with the curves and values marked thereon, bend it to fit the cylindrical barrel of the instrument and fasten it with screws.

Fig. 2 shows such a plate with the curves drawn thereon for pressures between 40 and 250 lb. gage. These curves have been plotted from the values given in Goodenough's steam tables, and the method of using them is very simple. To illustrate, suppose that the steam pressure in a certain test is 80 lb. gage and that the calorimeter thermometer shows a temperature of 250 deg. F. To find the quality of the steam under such conditions, the engineer puts the point of his pencil at 250 on the horizontal scale, moves it vertically upward till it strikes the diagonal marked 80 and then moves horizontally to the scale at the left, where the value 98 is found. Then the quality of the steam is 98 per cent.; or, the steam contains 2 per cent. of moisture.

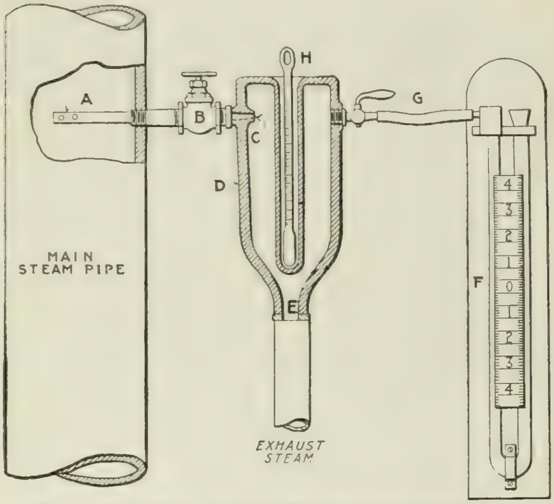


FIG. 1. GENERAL ARRANGEMENT OF THROTTLING CALORIMETER

If the observed pressure and temperature lie between the values marked on the plate, the position of the points can be judged closely enough to give the quality of the steam to within one-tenth of one per cent. of the true value. The lines on the plate may be engraved, etched or die-stamped.

This improvement makes the calorimeter self-contained and by its use it has been possible to train men in a very short time to make tests for quality of steam. It is no longer an instrument that needs outside assistance. The engineer takes a kindly interest in it, for it tells him at once what he wants to know without his consulting anybody or anything else.

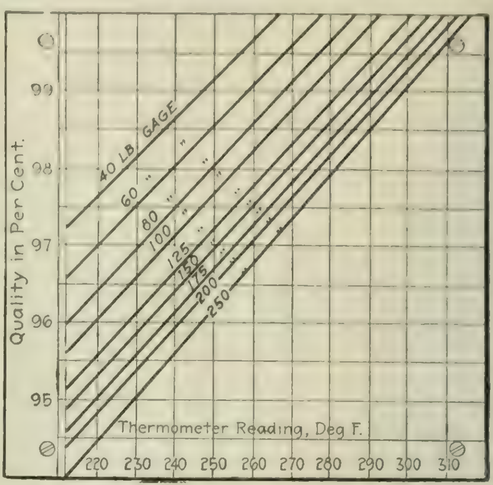


FIG. 2. CHART FOR FINDING QUALITY OF STEAM

The barrel of the average throttling calorimeter is about 3 in. in diameter and 6 in. long. Therefore, if the plate containing the curves is made 5 or 6 in. square, it will doubtless fit the outside of the barrel when it has been bent to the proper curvature.

Central-station service or isolated plant, and if central station shall it be municipally or privately owned, was the subject of a discussion between L. W. E. Kimball, representing the Brotherhood of Electrical Workers, and W. Rodman Peabody, counsel for the Turners Falls (Massachusetts) Power and Electric Company. The occasion was a hearing on a bill before the Massachusetts legislature providing for the establishment of a state commission to investigate the power resources of Massachusetts and to establish data bearing upon the public-ownership policy. Mr. Peabody, was legal adviser of the Massachusetts Fuel Administration during the war and has been identified with the Turners Falls hydro-electric and steam developments since their inauguration under the direction of Philip Cabot, of Boston. It is hardly necessary to say who took the pro and who the con of the argument, and our advices fail to show that any determinative thought or suggestion was evolved. It is interesting to know that the subject is still a matter of public discussion in the Old Bay State.

The friction of superheated steam is much less than that for saturated steam in passing through the engine steam ports and passages, and the sectional area of the steam pipe can be made smaller than that required for saturated steam.

EDITORIALS

Marking Time in the Coal Industry

STUDENTS of political economy sagely advise us that the prices of commodities are dependent on he relation of supply to demand, leaving out of consideration, of course, such artificial conditions as may be created by Governmental price-fixing or other methods of interference. Inasmuch as the control exercised by the Fuel Administration over the coal ndustry of the nation has been discontinued and all restrictions removed, it would seem as though the law of supply and demand ought to be functioning in splendid form; but it is not, and no one seems to understand just why.

The latest bulletin of the Fuel Administration announces that coal is more plentiful now than it is likely to be for a good while to come and advises retail purchasers to place orders at once for their next winter's requirements. Taking this announcement at its face value, the combination of a plentiful supply and a low demand ought to produce low prices. Instead, the very opposite has occurred. Not only have prices failed to fall, but the anthracite operators have declared an increase of ten cents a ton, effective April first, and there is no April-fool joke intended, either.

In all the tumult of conflicting testimony one fact stands out clearly. To go through a normal winter without discomfort, this country requires a definitely known amount of coal, so that the mining industry is fully aware of the minimum yearly demand. Fuel is a necessity, not a luxury. It cannot be dispensed with for any length of time without causing suffering. Therefore, the operators know that an amount of coal equal to the consumption in a normal year is bound to be absorbed by the domestic and manufacturing interests every twelve months.

What is to prevent the operator from anticipating this certain market by storing coal against the time of increased demand? Coal—particularly anthracite—does not deteriorate in storage, so there can be no objection to the practice from that angle. True, there is some breakage due to rehandling, causing degradation of size, and the expense of rehandling will add to the cost of the coal. But the practice of storing would keep the mines working continuously throughout the year, do away with part-time labor and insure a sufficient supply to meet the demand when cold weather arrived to stimulate the market.

Coal operators seem to be unanimously of the opinion that the wages of the miners will not be reduced. Many predict increases—or, what amounts to the same thing, a shorter working day without a corresponding reduction of wages. If this is assumed, it is apparent that the cost of production will not be decreased by waiting for more auspicious labor conditions.

To the man in the street the whole situation takes on the appearance of a freeze-out. The operator continues to run his mines on short time, content with producing just enough to fill the relatively small orders that come in. The mine worker submits to this state of affairs with as good grace as may be expected, but looks forward to improved conditions in the near future, his outlook having been considerably brightened by the adoption of the demands of British miners for a five-day thirty-hour week. The consumer, numbered by the millions, looks on with anger and dismay, undecided whether to put in his order now or not. And so the three sit tight, waiting, watching, hoping.

The distressing part of the situation is that the consumer has no chance to win. Whatever may be the outcome, he will be the victim. If the wages of miners remain unchanged, he will still pay increasing prices for coal, according to the schedule announced; if the wages of miners are raised, he will pay the increase, and then some; if he puts in his orders now, and coal prices should unexpectedly drop, he will be the loser; and if he holds off until cold weather compels him to order, he will be mulcted by the high prices that always prevail when coal must be had and the available supply is almost invisible. Confronted by such a hopeless situation, there can be little fault found with him if he does what the others are doing—marks time.

The 70,000 Kilowatt Turbine at Muscle Shoals

FEW steam turbines of greater than five hundred kilowatts had been built up to 1900. In this issue is described one of seventy thousand kilowatts, maximum. Such has been the sweeping progress in the interval.

The machine described is the one installed in United States Nitrate Plant Number Two, at Muscle Shoals, Alabama. It is of the compound, triple-cylinder, pure-reaction, parallel-flow type, consisting of a high-pressure turbine running at eighteen hundred revolutions per minute and two low-pressure, semi-double flow machines operating at twelve hundred revolutions per minute. Each turbine drives a generator.

The demand for greater capacity in one unit has led to the use of three cylinders, as exemplified in the seventy thousand-kilowatt, maximum, turbines, one in the Seventy-fourth Street Station, New York City, the other in the nitrate plant at Muscle Shoals, Alabama. In *Power* of September 15, 1914, Francis Hodgkinson, designer of the multicylinder reaction turbines in use in the United States, stated the advantages of such design to be as follows, saying that the reasons were more forcible the larger the capacity of the machine: Smaller cylinder structure; smaller temperature range within a cylinder; no limitations to the design preventing the attainment of the highest efficiency; possibility of separating moisture midway of the steam expansion.

The design permits also of low blade speeds, comparatively. In the machine described in this issue the mean blade speed in the last row of each low-pressure element is 514 feet per second. The water rate is best at fifty thousand kilowatts, at which load it is 10.55 pounds per kilowatt-hour at 290 pounds pressure absolute at the throttle, 175 degrees Fahrenheit superheat and 29 inches of vacuum.

The flexibility of this unit is of interest, particularly because it is the only main unit in the station now that plans for using a thirty-thousand-kilowatt machine have, for the time being, been abandoned. There are high pressure steam connections to the low-pressure elements, and should one or the other fail, or should the high- and one low-pressure element fail, the elements or element not incapacitated would continue to run. The reader will be interested in the automatic and manual control of the unit as told in the article.

Power-Factor Correction

IN SELECTING induction motors for a given drive it is of vital importance that the motors be chosen so that they will operate as near full load as consistent with standard-size machines. If a direct-current motor is only partly loaded, it results in a slightly lower efficiency and a higher cost of installation, which in many cases is offset by lower maintenance charges. However, when induction motors that are too large for the load they are to drive are installed, the cost of installation is not only higher and the efficiency of the motor lower, but the power factor is very materially decreased without any reduction in maintenance charges.

It is a well-known engineering fact that induction motors never, even when fully loaded, can operate at unity power factor. The best power factor that can be expected is approximately eighty-five per cent. lagging. However, when lightly loaded, the power factor is very low, resulting in low efficiency of the motor, distribution and transmission systems and generating equipment.

As the power factor decreases in a system, the current must increase in almost direct proportion to transmit the same power. With fifty per cent. power factor, to deliver the same power at the end of the line requires more than double the current flowing in the system as for unity power factor, which will increase the line and generator losses more than four times and reduce the available generator capacity at least fifty per cent., not considering the bad effects upon voltage regulation.

During the last three or four years the size of motors installed to do a given work has in many cases been dictated by the size that could be obtained and not what good engineering practice prescribed. If a five-horsepower was the proper size and earlier deliveries could be obtained on a ten-horsepower, the latter was not infrequently installed. Large manufacturing plants sprang into existence over night, the motors had to be obtained from somewhere, and practically the only consideration given was that they would operate on the power voltage available and large enough to carry the load. Consequently there are in operation many industries in which the motors are carrying only a small percentage of their rated load. This has resulted in a lowering of the power factor of a great many of the power systems all over the country, with its attending bad effects.

For some time past some of the larger central stations have offered inducements to their customers for maintaining their power factor above a certain prescribed value. However, owing to the conditions that have been brought about by the perfunctory installation of induction motors during the war period, this movement on the part of the power companies has become practically nation wide. Of course much can be done toward correcting the power-factor system by instal tion of synchronous apparatus in the various subst tions on the system of the power companies, but th place to correct the power factor to obtain the greate advantage is where low power factor occurs, which i most cases is in the plants that have lightly load induction motors. In almost every large industri plant there are some large drives that require constan speed motors and not excessive starting torque, whi can be just as successfully driven by large synchr nous motors as by induction motors. It is such driv that can be taken advantage of for power-factor co rection, the synchronous motor being selected larg enough not only to supply the power component the load, but also to supply a leading wattless component to neutralize at least part of the lagging wattless components due to the induction motor load.

There has been a tendency in the past by many o the industries that purchase power to consider th power factor of the system something for the powe company to worry about. But one has only to consider the result of low power factor to see that suc an attitude is erroneous. First, if induction motor are installed too large for the work they are to d the cost of installation is higher than it should be If the voltage regulation is poor the speed regulatio of the motor is also poor, resulting in a decrease i production and in some cases an inferior product. Th excessive losses in the distribution system and in th transformers, the latter where primary power is purchased, must be supplied from the generator in th power house and therefore passes through the meter at the manufacturing plant and appears as power use by the purchaser at the end of the month, consequentl this is not quite so much a one-sided question as a first might appear. This is especially the case in isolated plants, for the total losses due to lower powe factor are chargeable to the cost of manufacturing whether it is or not when power is purchased. However somebody has to pay the bills.

Reliable Refrigeration Data

IN ANOTHER column of this issue is an appeal on th part of a contributor for coöperation among engineers, especially on subjects pertaining to refrigeration Information is desired particularly on ammonia condensers and on the new designs of ammonia compressors, especially the high-speed type.

Power has always taken a stand in favor of mutua service. Its aim has been to be the means of spreadin information on steam and other allied engineering subjects. In its study courses, its specially prepared article and its correspondence columns it attempts to make i possible to keep the operating and designing engineer thoroughly up to date.

In the matter of refrigerating data it seems especially necessary to ask our readers to send in their information. For some reason or other it appears tha engineers are not progressing as satisfactorily in the refrigerating field as in other branches of engineering so far as gaining reliable facts is concerned. The refrigerating companies are too busy or are not properl equipped to obtain test data. Enthusiastic claims are sometimes made on special designs or new machines which are not substantiated in practice. It is clear then, that reliable data can be obtained best from the field—by the owners or the operating engineers.

Correspondence

Water-Column Blowoff Valve

Having numerous high-pressure boilers in my charge, I have had considerable experience with water-column owoff valves. The letter by R. A. Williams on page 0 of the Jan. 28 issue of *Power* brought to mind ny of the troubles I have had from these valves king. Mr. Williams says that he extended the pipe om the bottom of the gage-glass and put the blowoff lve on the lower end of the pipe. On all large boilers ese valves are located as he states, but the valves our boilers continued to leak.

After looking into this matter to find out why these lves should give so much trouble, I discovered that the globe valves were so placed that the pressure, en closed, came under the disk, Fig. 1, so that the lve stem might be packed while the boiler was under essure.

It was then decided to pipe all water-column blowoff lves so that when closed the pressure would be on the p of the seat. The reason for doing this was that hen blowing down the water column with a valve set that the pressure came under the disk, the stem ould be heated to the temperature of the steam in the iler, and the expansion of the stem would be gov- ned by its temperature. Then after the valve had en closed long enough for condensation to take place, e stem would contract and allow the valve disk to ave its seat. This would cause the valve to leak unless e attendant turned the valve wheel to take up the con- action that had taken place.

But when placed so that the pressure comes on the p of the disk when closed, Fig. 2, the disk will be ld in place without being forced to the seat by the lve stem. With this method of piping, our valves ave given many times the service they did before the ange was made.

THOMAS J. PASCOE.

Norway, Mich.

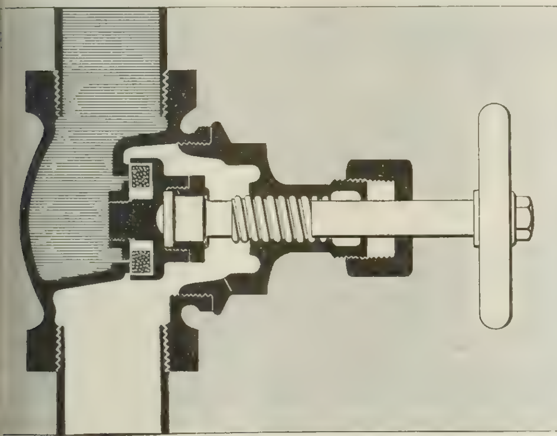


FIG. 1. PRESSURE UNDER THE VALVE DISK

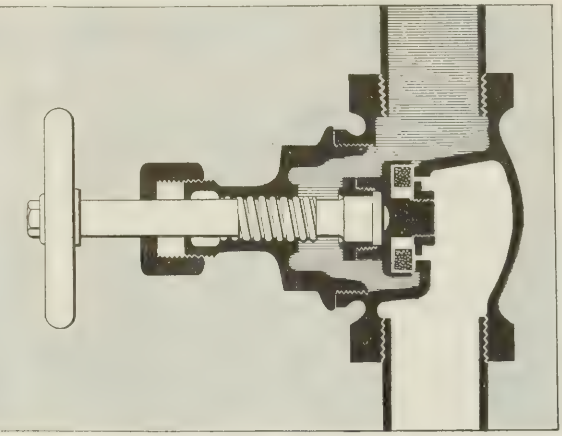


FIG. 2. PRESSURE ABOVE THE VALVE DISK

Overheating Hot Water Wasteful

I have been interested in the articles that have appeared in *Power* regarding the overheating of hot water, and while the contentions brought out by various engineers are correct as far as they go, it seems to me that there is one point that they have overlooked, and this applies especially to office buildings and factories where a large quantity of water is used by the people in the washrooms.

The common practice in many instances is to have a combination hot- and cold-water valve, and by turning the valve handle a certain extent various degrees of temperature of the water coming from it may be obtained. If the hot water is at a high temperature, the user will generally be obliged to turn the valve wide open in order to get enough cold water to temper the flow so that it can be used without scalding. Under such circumstances much water goes to waste, in fact three or four times as much as would be used in case a lower temperature of hot water were carried.

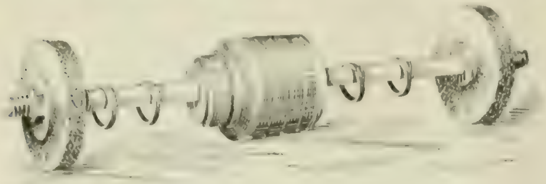
This same thing can happen in the case of wash basins, where the custom is to open both the hot- and cold-water faucets, and if the water is at a high temperature the water in the bowl is too hot to use, and consequently more cold water is run into it to bring the temperature down; so much so that a large quantity generally will escape through the overflow. Of course this is a waste of water, both hot and cold, and such waste will bring the cost of the raw water up considerably in the course of the year.

Not only is cold water wasted in quantity, but the heat used in bringing the hot water up to a high temperature is lost in part, as more hot water is used than is necessary, and it goes to the waste pipe.

Paterson, N. J. L. A. HIGGINS.

Why Do Oil Rings Wear Grooves in Shaft?

I have had considerable trouble with a motor-driven grinding machine used for grinding steel castings. This trouble is confined to the bearings, which are of the ring-lubricated type, and the rings wear a groove in the steel shaft, although the bearings are supplied with plenty of oil. They are in line and run cool. So far the only remedy has been to put in a new shaft, but in a short time the grooves are worn the same as before.

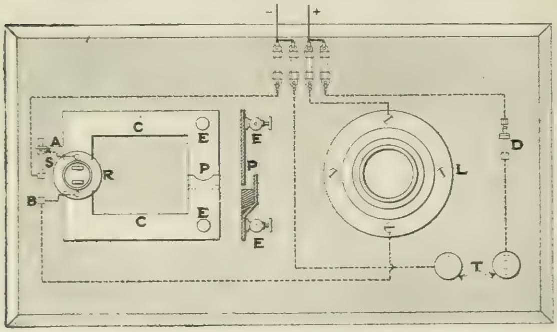

COPPER RINGS WORE SHAFT

The shaft runs at 960 r.p.m. and is 3 in. diameter. The oil rings are of copper. Can anyone who has had a similar experience suggest a remedy for the difficulty? **William H. Roberts.**

Lima, Ohio

A Convenient Arrangement of Plug-Fuse Test Board

I have been interested in the articles on electrical testing outfits appearing in *Power* and have constructed a test board of an arrangement somewhat different from any other I have seen, which has proved to be a very useful device about the shop. The figure indicates the construction of the board. Plug fuses are tested by placing them at *P* and closing switch *S* to *A*, and cartridge fuses are tested by placing them so that their ferrules rest on the brass strip *C*. These strips are connected to the terminals of a receptacle *R* from which an extension cord may be taken for testing equipment on the bench or shop floor. The receptacle may be replaced by binding posts *E*, as shown. Terminals *T* are for supplying power, by closing switch *D*, to any small equipment that comes within the capacity of the fuses mounted on the board. By closing the switch *S* to *B* the lamp *L* will burn continuously and may be used for lighting around the bench. **W. W. Parker.**



ARRANGEMENT OF DEVICES ON TEST

Electrical Division, U. S. S. "Texas."

New Design of Crank-Rod Wedge Adjusting Bolt*

The frequent references to breaking wedge bolts in the correspondence column of *Power* are of special interest to me, as I have had numerous experiences with this troublesome occurrence and have been called upon to replace these bolts when the connecting-rod had to be removed to let the new bolts in. I have also seen wrecks caused by pieces of broken bolts becoming wedged in some part of the engine.

Some causes of breakage may be eliminated, such as holes out of line, poorly fitting wedges, etc., but I have had engines that would break the bolts in time no matter how carefully they were fitted. I had charge of a large gas engine that gave considerable trouble in this way, and after many shutdowns and various experiments I developed a design of wedge bolt and lock which seem to be immune from destructive forces. I have tried this bolt out thoroughly on gas and steam engines and can guarantee it to stand the strain put upon it.

Fig. 1 shows the original bolt, which is provided with a hole for a key wrench, also a cross-section showing the lock setscrews with copper shoes on the threaded ends. Fig. 2 is a modified form using a common header bolt. This works well in practice except that the wedge cannot be loosened by turning the bolt.

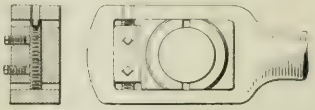


FIG. 1. ORIGINAL BOLT

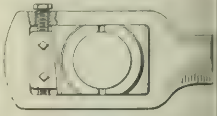


FIG. 2. MODIFIED FORM OF FIG. 1

It may appear that the wedge would jump, but in actual practice on high-speed engines I have found it is entirely satisfactory. In applying this bolt I plug the bottom hole in the strap of the ordinary design of rod and dress it off evenly. The outstanding feature of this bolt is that it is subject to compression only and it is free to float with the wedge, and the long thread through the wedge makes a powerful jackscrew that is easily locked and will not break.

I have adopted the bolt shown in Fig. 1 and consider it to be more practical, though a little harder to make and apply. The bolt must strip the long thread o be crushed before the wedge can get loose, and I have not yet seen the engine that will do it. After using this bolt for about two years with heavy-duty and high speed gas and steam engines that were in the habi of breaking bolts made from special materials, I hav satisfied myself that my arrangement will stand th test.

A wedge bolt is an insignificant part of an engine and as long as it holds it is seldom thought of; bu when it breaks and the brasses get the full play of th strap an engineer is out of luck. I know from experience that it is a mighty consoling feeling to know tha the bolt will not break and especially so when ther are hundreds of workmen depending on the engine fo power, to say nothing of the loss of production.

Oil City, Penn. **Lloyd R. Hoffman.**

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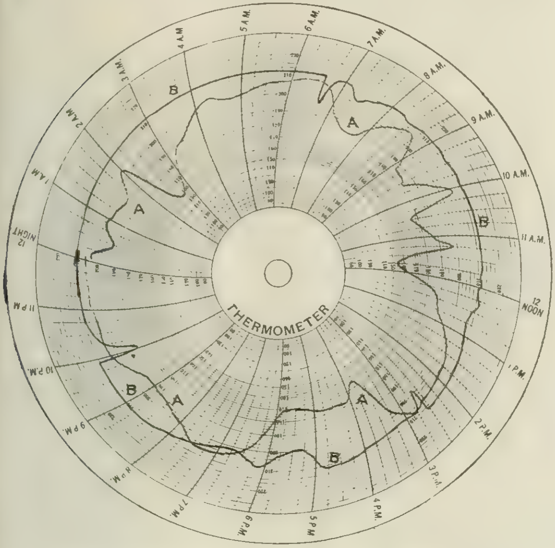
*Patent applied for.

Using Charts Over Again

The accompanying chart is for the same date of last year and this year where the operating conditions were practically the same, and shows two chart records.

A red line *A* is for Feb. 3, 1919, with an average feed-water temperature of 193 deg. F., and a green line *B* is for Feb. 3, 1919, with an approximate average temperature of 209 deg. F. The operating conditions on both days were practically the same, but on Feb. 3, 1919, 3600 lb. less coal was burned than on the same date last year. The outside temperature on Feb. 3 last year was 22 deg. F.; the average outside temperature on Feb. 3 this year was 31 deg. F., taking it for the entire 24 hours.



TWO TEMPERATURE RECORDS ON ONE CHART

I mention the temperature because it has an important bearing on the operation of the plant. This comparison shows very plainly to me what a fireman can do if he feels like it. Of course the higher temperature this year would account for some saving in coal, were it not for the fact that the coal burned was very much poorer than what we had last year, and would, I am sure, offset any saving due to higher outside temperature. W. R. GROOM.

New York City.

What Makes the Exciter's Voltage Slow To Build Up?

In our plant we have two steam-engine driven 110-kv.-a. 2300-volt alternators, with a 7.5-kw. direct-connected compound-wound exciter on each. The machines are not operated in parallel since the power requirements are such as to make this unnecessary. The voltage of each machine is controlled from the same regulator.

One of the machines will respond quickly to load changes and the other is sluggish. The exciter on the sluggish machine is slow to build up its voltage, consequently the alternator is slow in coming up to full potential. It sometimes requires 10 to 15 minutes for the exciter to come up to its full rated volts when first started. If the series- and shunt-field windings are in opposition, would this cause the trouble? I would like to hear the opinion of *Power* readers as to the cause of the difficulty. I might add that the alternators are supplying power to mine motors and at times there is a swing from practically no load to full load. What is the answer? C. S. HARRISON.

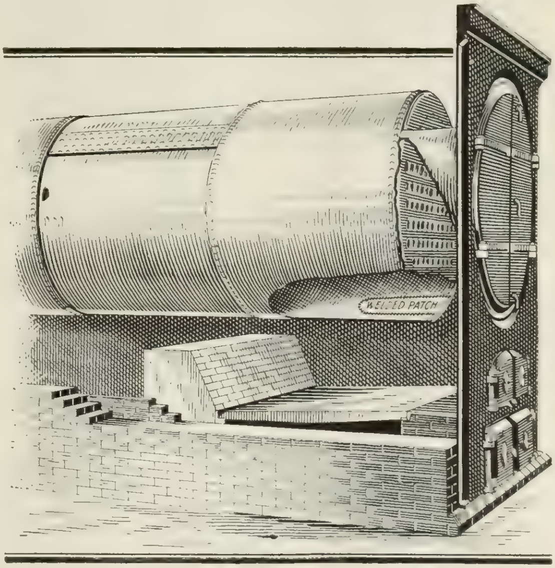
Courtland, Ariz.

Boiler Patch Welded In

To those interested in welding of boiler plates by the oxyacetylene method, a weld made on a boiler in the Western Commercial plant at Wayne, Alberta, may be of interest.

This is a plain return-tubular boiler and was supplied with water by an injector from a stream carrying considerable mud. Mud collected over the fire sheet, and a bulge formed about the size of a man's head. This bag was close to the head so that the plate was cut out from the head back far enough to take out all damaged material, and a patch was riveted on in the ordinary manner.

Much trouble was experienced with this patch leaking, and the inspector finally gave his consent to try a weld. The shell was again cut out from the head back, taking out all rivet holes, and a patch was cut to fit the opening and placed inside the boiler plate and welded so that the two plates are on the same plane and not lapped. The boiler was tested up to 200 lb. gage with hydraulic pressure and is now working under a steam pressure of 125 lb. So far it has proved a good piece of work and no further trouble has been experienced. H. E. WIGHT.



PATCH WELDED TO FIRST SHEET OF RETURN-TUBULAR BOILER

Drumheller, Alta., Canada.

(The Code of the American Society of Mechanical Engineers does not allow the use of a weld under pressure unless the stress is taken up independently of the weld.—Editor.)

Throttle Had Too Much Play

I was recently called to a plant that has a 1500-hp. cross-compound Corliss engine driving textile machinery. The engine suddenly showed difficulty in taking care of the regular load of about 1000 hp. Indicator diagram *A*, Fig. 1, had been taken a few days previously, but card *B* was the best that could be obtained when I arrived. The dropping steam line showed wire-drawing, a throttling effect on the steam, or the piston leaking badly.

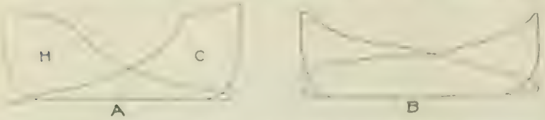


FIG. 1. TWO SETS OF DIAGRAMS FROM SAME ENGINE

Notes of the water used in the condenser showed no increase over previous days, and equally good vacuum eliminated the possibility of a faulty piston. A steam gage at the receiver separator near the throttle showed practically full boiler pressure, so the trouble evidently was at or near the throttle valve. This valve was one that opened away from the operating wheel, having a left-hand thread on the stem, Fig. 2. The stem also actuated the bypass.

The cover was removed from the valve after work hours, and it was found that the nut holding the valve disk in place had moved back to such an extent that the main disk remained on the seat when the stem had reached its limit, allowing cnly the steam that passed through the bypass to operate the engine, which was carrying about 66 per cent. of full load. After replacing the nut, allowing only ¼ in. play for the bypass opening, a new card was taken, showing a return to normal conditions. JOHN F. HURST.

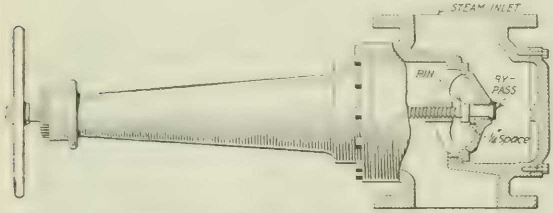


FIG. 2. TYPE OF VALVE THAT GAVE TROUBLE

Louisville, Ky.

Reliable Refrigation Data

Refrigeration is one of the growing branches of engineering as one can see by the yearly reports of sales of refrigerating apparatus or by the recent increase in the American Society of Refrigerating Engineers. On every hand we see new applications where its usefulness was unknown or neglected a few years ago.

This being the case, I want to appeal to *Power* and *Power* readers to assist in developing the art. Mechanical refrigeration is new; it is a growing subject and one relatively neglected. Very little reliable information is published, for in almost every case there is some personal motive in circulating the information, as in the celebrated horsepower per ton of refrigeration data. What the art requires is unbiased, up-to-date information on condensers, compressors, pumps and piping. It seems strange that such a simple piece of apparatus as an ammonia condenser should be so shrouded with secrecy as is at present apparent.

I therefore appeal to the operating and designing engineer to come forward and help those of us who would like to learn and cannot because of lack of available information. And I ask *Power* to make this possible by hearty coöperation in throwing open its columns to a general discussion on this very important branch of engineering. H. J. MACINTIRE.

Seattle, Wash.

Eliminating Cylinder Oil from Exhaust Steam

The manner in which W. H. Wakeman described the method employed in reducing the speed velocity of steam in the oil separator, page 365 of the Mar. 11 issue of *Power*, will probably be of assistance to others in eliminating oil troubles in their feed-water due to similar causes, but it would appear that the suggestions made to the engineer in charge, to the effect that the separator was not properly located, were correct.

According to most engineers the separator, in regular practice, should be placed between the engine and the heater so as to prevent oil from getting into the heater and coating the tube-heating surface and thus reducing the heat transfer of the exhaust steam to the water in the heater. The 12-in. connection between the heater and the separator could have been made between the 8-in. ell on the exhaust pipe and the separator just as well, and would probably have given just as satisfactory results and at the same time have prevented oil from entering the heater. L. A. HIGGINS.

Des Moines, Iowa.

Steam-Gage-Glass Marker

A marker of some kind is usually placed on steam gages, etc., when they are to be read from a distance or when it is desired to read them readily without going close up to see if the pointer is where it should be. Generally, an arrow or some such mark is painted on the gage, but a better plan is to paint the marker on the glass of the gage and then if at any time it is desired to change the point of reading, it will not be necessary to paint a new marker. Shifting the glass to the new position answers the purpose.

Norristown, Penn. WILLIAM H. WATSON.

Simple Tempering Method

Tempering a drill, cold chisel or other tool properly requires quite a knack, but there is a sure method that requires no skill. First heat the point of the tool to be tempered to a cherry red and then force it into a bar of lead, keeping it there for about half a minute. Then cool it in water. That is all there is to it.

To save the temper of a tool, as for instance an ax in which the handle has been broken off and the stub end cannot be driven out easily, drive the cutting edge of the ax into moist ground and then place live coals around the head. When the wood becomes charred, it can be driven out and the temper in the cutting edge will have been preserved. JAMES E. NOBLE.

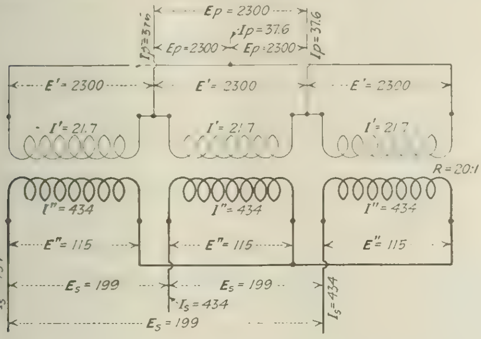
Kingston, Ont., Canada.

Prepare for Prosperity through the Victory Liberty Loan.

Inquiries of General Interest

Delta to Star Connected Transformers—When three single-phase 2300- to 115-volt 50-kv.-a. transformers are connected delta in the primary and star in the secondary, what will the voltage and current values be in the system when the transformers are fully loaded? J. G. B.

Since the primaries of the three transformers are connected delta, the voltage E' across the terminals of each transformer will be that of the line, or 2300 volts, and the secondary volts E'' of each transformer will be the primary volts divided by the ratio. The ratio in this case is 2300 : 115, or 20 : 1. Then the secondary volts across each transformer $= \frac{2300}{20} = 115$. Since the secondary windings are connected in star, the voltage E_s between terminals is that of one transformer times $\sqrt{3} = (1.732)$, or $115 \times 1.732 = 199$ volts. The full-load primary current I' of one transformer will equal its full-load kv.-a. times 1000 divided by its primary voltage, or $50 \times 1000 \div 2300 = 21.7$ amperes. The primary windings are connected delta, therefore the current I_p per terminal will equal the primary current I' of one transformer times $\sqrt{3}$, or $21.7 \times 1.732 = 37.6$ amperes. In the secondary winding of each transformer the current I'' will equal that in the primary windings times the ratio, hence $I'' = 21.7 \times 20 = 434$ amperes. With the secondaries connected in star the current I_s per terminal is the same value as in the windings; that is, $I_s = I'' = 434$ amperes. The kv.-a. of the bank is the total capacity of the three transformers, or $50 \times 3 = 150$. The distribution of the current and volts is indicated in the figure. Of course these values are only theoretical; the loss of about 3 per cent. in the transformers will change the figures slightly.

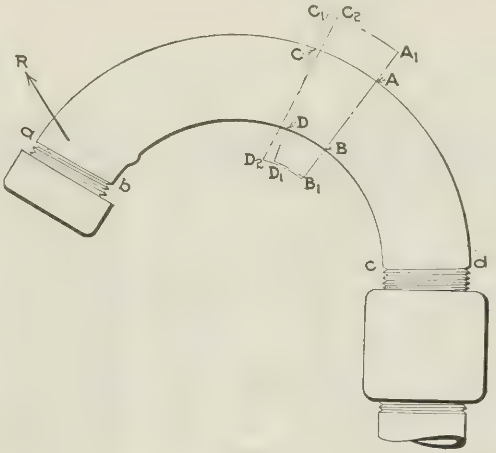


Determining Belt Slippage—How can we tell when belts are slipping, and what instruments should be used to determine the percentage of slippage? A. B.

Serious slippage of a belt on a pulley usually is accompanied by a noise varying from a dull swishing to a sharp screeching. The only time that no slippage takes place is when the angular velocity of the belt, in passing around with the pulley, is the same as the angular velocity of the pulley. Assuming that the average lineal velocity of the belt is the velocity at the center of its thickness, normal belt velocity without slippage should be estimated as equivalent to the peripheral speed the pulley would have if its radius were equal to the actual radius plus one-half the belt thickness, or as if the diameter were equal to the actual diameter plus the belt thickness. There are excellent revolution counters on the market by which the r.p.m. is shown at sight. For determining the actual speed of a belt, use an instrument like a cyclometer, operated by a projecting finger attached to the belt, for counting the number of times per minute a point on the belt passes a stationary point to which the cyclometer is attached. The length of belt multiplied by the number of revolutions made by the belt per minute will give the actual belt speed per minute. This, divided by the peripheral speed that would be due to a driving pulley whose diameter is equal to the actual diameter plus the belt thickness will give the percentage of efficiency. The efficiency of the belt drive on the receiving pulley would be the peripheral speed due to the pulley diameter plus belt thickness, divided by the actual speed of the belt. For obtaining the total efficiency, multiply the r.p.m. of the follower by its diameter plus the belt thickness and divide by the product of the r.p.m. of the follower pulley and its diameter plus the belt thickness. In any case the percentage of slippage would be 1 minus the percentage of efficiency.

Action of Bourdon Pressure-Gage Spring—What causes the bent tube spring of a Bourdon pressure gage to straighten out for pressure and become more curved for a vacuum connection? C. W.

Suppose *abcd* to be a bent pipe of any cross-section, made of elastic material and having a free end *ab* stopped off, and subjected to internal pressure of steam or air introduced at the supported end *cd*. When inflated, the pipe would expand in diameter, and by sufficient pressure a point like *A* would have a tendency to move outward radially to a position A_1 and a point at *B* would have a tendency to move radially to a position B_1. In the same manner there would be a tendency to carry the point *C* to C_1 and *D* to D_1. But for actual radial movement the distance C_1 to A_1 would need to be greater than *CA*, and D_1B_1 would be less than *DB*, and if the material around the outer curve of the bend was not sufficiently elongated, or the material along the inner curve was not sufficiently compressed, the material originally located along the section *CD* would assume a sloped position like C_2D_2. Hence for increase of internal pressure the free end of the tube would be carried upward in the direction of the arrow *R* by the cumulative action of succeeding sections, or in other words, it would become straighter; while for a vacuum or collapsing pressure of the atmosphere, the curvature would be increased because the bending forces would be the reverse from those resulting from inflation. For greater sensitiveness the spring tubes of Bourdon pressure gages are flattened or elliptical in cross-section, with their shorter axis normal to the curvature of bend.



Fusion in Arc Welding*

By O. H. ESCHHOLZ

Calls to attention such characteristics as penetration and overlap, peculiar to the metallic-electrode arc-welding process, which facilitate visual inspection, and discusses briefly the effect of arc length, welding procedure, electrode material, arc current and electrode diameter upon these characteristics.

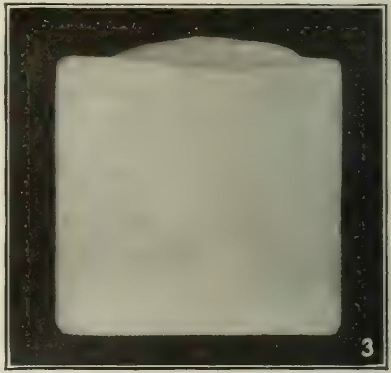
THE physical characteristics of a weld are admittedly determined chiefly by the degree of fusion secured between adjacent metals. In the production of welds by the metallic-electrode process, a fair estimate of the fusion may be obtained by an examination of the surface of the deposited metal and the depth of the arc crater formed when welding at normal speed. These observations give an adequate indication of the two prime characteristics of fusion—penetration and overlap—which, however, are definitely revealed only on exposing a section through the zone fusion.

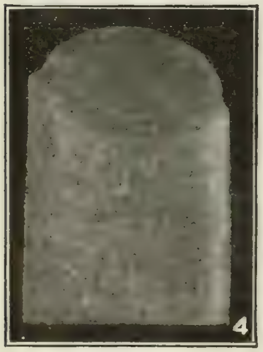
Figs. 1 and 7 illustrate the union between a layer of metal deposited from a low-carbon steel electrode upon a low-carbon steel plate. The line of demarcation between the plate and deposit indicates the zone of fusion, the polished and etched surface of the deposited material presenting a different appearance, due to its crystalline structure, from that of the plate material. Two characteristics are at once apparent—a penetration of the deposited metal into the plate metal over almost the entire width of the layer, and a slight overlapping upon the plates without fusion of the extreme edges of the deposit. The penetration is due to liquefying of the plate metal by the energy absorbed from the arc as well as that absorbed from the molten deposit.

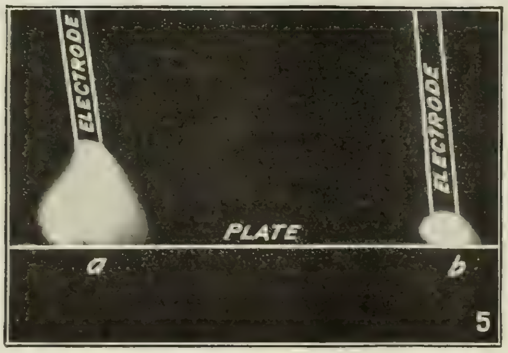
At the center of the deposit, where both effects are present, the penetration is greatest; at the extreme edges, however, where the deposit has overflowed the area included by the arc crater, the energy liberated on cooling is insufficient to melt the plate metal and the deposit congeals without fusing to it. It is typical of such overlapping that the edges of the deposit are well rounded, a distinct gap often existing between the plate and edge of deposit. The convex of the deposit thus forms a reentrant angle with the plate edge. To insure satisfactory fusion a proper degree of penetration should be obtained with no overlap.

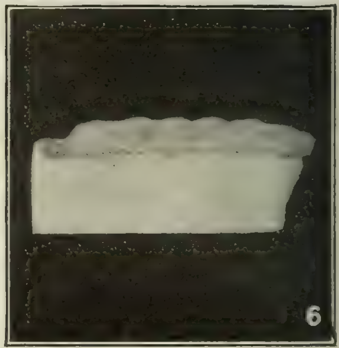
Figs. 2 and 8 show a section through the crater obtained on breaking an arc during the process of depositing a layer of metal on a steel plate. It may be observed that the depth of the crater depression is comparable to the depth of penetration of the deposited metal below the plate surface. A simple visual indication is, therefore, available during the welding operation for gaging the penetration.

The convex edges of the deposit shown in Fig. 2, par-









FIGS. 1 TO 6 PHOTOGRAPHS OF SECTIONS THROUGH ELECTRIC-ARC WELDS

Fig. 1—Section through a layer of metal deposited on a mild steel plate, when using a short arc and a proper welding current. Fig. 2—Section through the crater remaining on interrupting the arc current. Fig. 3—Section of deposit obtained with a long arc, indicating excessive overlap and practically no penetration. Fig. 4—Absence of overlap when depositing metal of a high-melting point on a plate of low-melting point. Fig. 5—(a) Long arc. (b) short arc. Fig. 6—Section through the center of a deposited layer in the direction of forming the deposit.

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*Paper presented at a joint meeting of the American Institute of Electrical Engineers and the American Institute of Mining Engineers, held during the Midwinter Convention of the American Institute of Electrical Engineers, New York City, February, 1919.

ticularly evident at the right of both Figs. 1 and 2, would lead one to expect an appreciable overlap. This is disclosed on a careful inspection of the sections, Figs. 7 and 8. A surface contour with no overlap is shown in Fig. 4. This condition is usually typified by the absence of even the smallest reëntrant angle, an intimate contact between plate and deposit being secured, the junction between the two metals often forming a concave surface.

A condition of extreme overlap is shown in Fig. 9. This is typical of a low-melting point electrode or of too great speed of arc travel. The convex deposit edge and the reëntrant angle between it and the plate are pronounced.

The effect of fusion of arc length has been discussed at considerable length by welding engineers. Some assert that better fusion is secured for a given arc current with a long arc than with a short arc, owing to the greater amount of energy absorbed by the arc; others have stated that the degree of fusion is dependent solely on the arc current and, of course, the thermal characteristics of the metal welded. For a given arc current it has been the author's experience that fusion is not improved with increase in arc length, that the best weld characteristics are obtained when holding a short arc, not longer than $\frac{1}{8}$ in. and preferably about $\frac{1}{16}$ in. With a given arc length the ease of securing complete fusion increases with arc current until a maximum value is reached beyond which further increase results in a weakened weld structure.

Figs. 1 and 3 are typical of sections through deposits formed with a short and a long arc respectively, the arc current being approximately the same in each instance With a short arc the plate metal is liquefied by the energy required to maintain the arc crater, by that conducted from the arc flame in constant intimate contact with the plate and by the energy radiated from the arc stream and electrode terminals, as well as by that absorbed from the molten-electrode deposit. When the molten material passes through a short arc it is quite completely enveloped by hot gases and suffers but slight loss in temperature before being deposited. Upon drawing a long arc the air currents in its vicinity blow the arc stream and arc flame about violently, so that it is difficult to maintain the plate terminal of the arc in a given position long enough to effect sufficient penetration. Moreover, the energy absorbed from the arc stream and electrode terminal becomes practically negligible, due to the greater diffusion of the radiation in the region of the arc plate terminal, while the energy absorbed from the molten metal is decreased because of the loss in temperature the deposit has sustained in transition. Some conception of the appearance of short- and long-arc lengths may be obtained from Fig. 5.

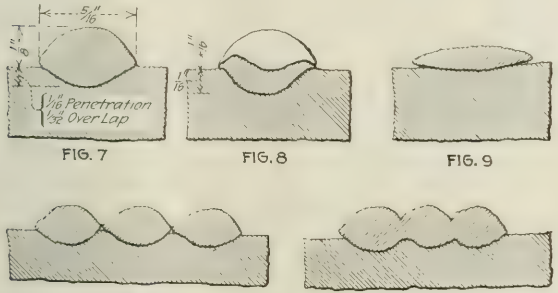

FIG. 7 FIG. 8 FIG. 9

FIG. 10 FIG. 11

FIGS. 7 TO 11. SECTIONS THROUGH METAL DEPOSITED BY THE METALLIC ELECTRODE PROCESS

The extreme condition of no overlap is difficult to secure when depositing a single layer of electrode metal upon the usual low-carbon steel plate. For most purposes a slight overlap, such as indicated in Figs. 1 and 7, is permissible in single layers as a simple procedure of depositing the subsequent layers will fuse the overlapped areas.

Fig. 10 illustrates the characteristic penetration and overlap when parallel abutting layers are formed. The minimum overlap for this condition will approach $\frac{1}{16}$ in. per layer. If the width of a layer is increased by weaving the electrode back and forth, the percentage overlap will be decreased. However, it may be eliminated by the simple expedient of always overlapping adjacent layers as shown in Fig. 11. On forming the second tier of deposits, the same precaution should be taken to prevent unfused zones. Fig. 6 shows a typical section through the center of a layer. It may be noted that although the depth of penetration varies somewhat, owing to the speed of arc travel and unavoidable variation in arc length, good fusion has been secured between the plate and deposit along the entire length of the deposit.

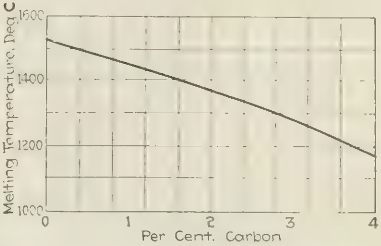

FIG. 12. MELTING POINTS OF IRON ALLOYED WITH VARIOUS AMOUNTS OF CARBON

Since the choice of electrode material, arc current and electrode diameter largely determine, with a given manipulative skill and welding procedure, the depth of arc crater and deposit contour, a brief discussion follows of such characteristics, which affect fusion between the deposit and plate metals.

To minimize the occurrence of unfused areas, the melting point of the electrode metal should exceed that of the plate metal. Fig. 1 illustrates the fusion obtained with the melting points approximately equal (0.18 per cent. carbon, 1510 deg. C. approx.), Fig. 4 that secured with a greater melting point for the electrode (0.18 per cent. carbon, 1510 deg. C. approx.) than for the plate (3 per cent. carbon, 1280 deg. C. approx.), and Fig. 9 that obtained with a lower electrode melting point (1.1 per cent. carbon, 1440 deg. C. approx.). The melting point of most weldable steels may be gaged with sufficient accuracy for welding purposes by the carbon content, as shown in Fig. 12. The usual additions of other alloying ingredients reduce the melting point a negligible amount.

While pure iron possesses the highest melting point, its use is not advisable since excessive oxidation of the vaporized metal occurs. However, a commercially pure iron alloyed with about 0.18 per cent. carbon and 0.5 per cent. manganese greatly reduces the oxidation and improves the ease of manipulation without an appreciable sacrifice in melting point. For most purposes the use of this electrode gives a reasonable minimum overlap.

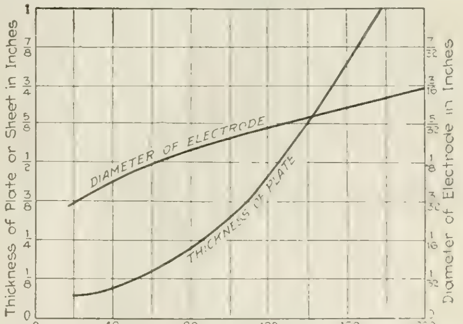

FIG. 13. APPROXIMATE VALUES OF ARC CURRENT AND DIAMETER OF ELECTRODES

Under exceptional conditions such as high thermal capacity of weld, or overhead welding with a low current, the overlap may be excessive even when using this electude, it is customary then to preheat the object to be welded or to adopt a welding procedure which utilizes the thermal energy from preliminary welding operations to raise the temperature of the object welded.

For a given plate thickness the welding current will vary with the type of weld scarf, cleanliness of surface, thermal capacity and conductivity of the metal, and position of plate with respect to the welder. The values shown in Fig. 13 apply only to clean, butt-welded plates, single V, scarfed to 90 deg., supported in a horizontal position below the welder, in poor thermal contact with any metal of high thermal capacity. The fusion obtained with too low and too high arc currents is shown in Figs. 14 and 15 respectively. In Fig. 14 the overlap is excessive and the penetration unsatisfactory because of the small amount of energy applied at the arc crater. In Fig. 15 the excessive energy consumption at the plate arc terminal produces excessive penetration, a further increase in current permitting cutting through the plate.

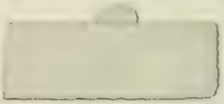

FIG. 14. FUSION SECURED WITH TOO LOW ARC CURRENT

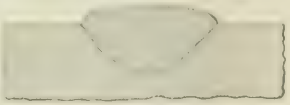

FIG. 15. FUSION SECURED WITH TOO HIGH ARC CURRENT

Fig. 16 indicates approximately the effect of variation of arc current on fusion and therefore on weld strength for (curve *A*) skilled and (curve *B*) unskilled welders. Weld structures are occasionally encountered in which variations in thermal capacity and plate temperature necessitate changes in arc current if complete fusion is to be secured. Observations of the deposit contour and crater depth usually serve to indicate to the operator when such changes are advisable.

A close adjustment of electrode diameter to arc current is not essential. For miscellaneous direct-current welding the densities usually fall within a range of 7000 to 10,000 amperes per sq.in. if an 0.18 per cent. carbon-steel electrode is used. However, whenever practicable, the author prefers a closer range of 8000 to 9000 amperes per sq.in. With too great an electrode diameter for a given current, the arc becomes more unstable, increasing the manipulative skill required and decreasing the rate of depositing electrode material. Too small a diameter causes a deposition of electrode material before the plate has been properly liquefied; it also results in overheating and softening of the electrode, which increases the skill required to prevent the electrode from "freezing" to the plate. With the correct diameter the electrode material is sprayed in a regular stream at a rate that will insure maximum welding speed consistent with good fusion.

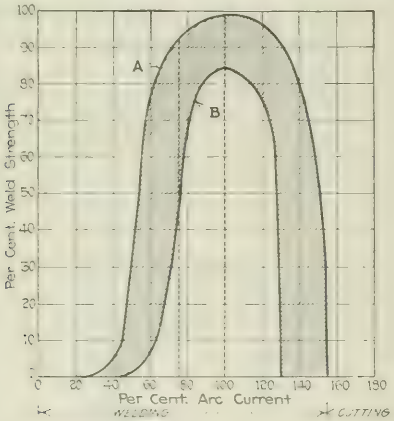

FIG. 16. CHANGE IN WELD STRENGTH WITH CHANGE IN ARC CURRENT

For example, the characteristics of fusion and the effect of a control of the conditions that govern them may be summarized in comparing the procedure for making butt and lap welds.

In butt-welding $\frac{3}{8}$-in. low-carbon steel plates, scarfed as shown in Fig. 17, a $\frac{5}{32}$-in. diameter welding electrode containing approximately 0.18 per cent. carbon, 0.5 per cent. manganese, would preferably be used with an arc current of approximately 150 amperes. With moderate skill the strength of weld should approximate 90 per cent. that of the plate. If the same current and electrode diameter are used in welding the lap joint formed from $\frac{3}{8}$-in. plates shown in Fig. 18, poor fusion will be obtained owing to the increased thermal capacity of the abutting sections. As shown in Fig. 18 the penetration will be too slight and the overlap excessive, similar to the case shown in Fig. 14. In fact, sections through completed lap joints most invariably show that in forming the first deposit, which is the most important, even expert welders tend to penetrate only one side of the weld scarf with resultant overlap on the other. Breakdown tests of lap joints have plainly shown failure due to this cause.

To secure complete fusion on both faces of the joint, it is necessary to increase the arc current and with it the electrode diameter. For the condition shown in Fig. 19 an arc current of 225 amperes and an electrode diameter of $\frac{3}{16}$ in. was found to produce complete fusion, facilitate electrode manipulation and increase rate of electrode deposition.

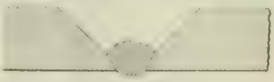

FIG. 17

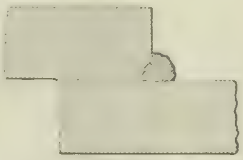

FIG. 18

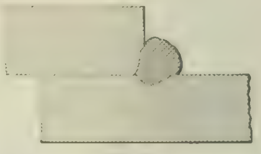

FIG. 19

FIGS. 17 TO 19. SECTIONS THROUGH BUTT AND LAP WELDS MADE UNDER DIFFERENT CONDITIONS

In conclusion it may be said that the fusion obtained in arc-welded joints between the plate and deposit metal is determined by the penetration of the deposit metal into the plate metal and the overlap of the edge of the deposit layer on the plate. The penetration is comparable to the depth of arc crater as observed by the welder when moving the arc terminal over the plate with uniform velocity, and the overlap is indicated by the contour of the surface of the congealed deposit in the region adjacent to the material welded. For most welds a crater depression of $\frac{1}{16}$ in. will give the desired penetration, while a contour that does not show a reëntrant angle between plate and deposit indicates an overlap per layer of approximately $\frac{1}{32}$ in. or less.

The Engineer as a Citizen

Under the auspices of the local sections of the several national engineering societies a symposium was held on Wednesday evening, Mar. 26, in the Engineering Societies Building, New York, to discuss how engineers individually and collectively might take a more active part in public affairs. The program included addresses by half a dozen engineers prominent in the fields of electrical, mechanical, mining and municipal engineering, and was followed by discussion of a profitable nature.

Gano Dunn, past president and fellow of the American Institute of Electrical Engineers, presided and after a short introductory address touching upon the need for engineering council in these times, called upon Philip N. Moore, past president of the American Institute of Mining Engineers, whose topic was "The Civic Responsibility of the Engineer." "Present conditions as regards the engineer's relation to public affairs," said the speaker, "are traceable largely to past indifference to political activities and civic duties." This indifference he attributed to several causes, among which were lack of local attachments, business connections sometimes adverse to public interests, too technical training, and the habit of keeping aloof. The remedy for this isolation lay primarily within the engineer himself and secondly within the societies. Touching upon present economic conditions the speaker urged that brains must always rule brawn; that labor, if it would share in profits, must also be ready to share in losses; and that at no time has there been greater need for engineering thought and clear reasoning to offset unsound reform.

The next speaker, Calvert Townley, discussed "The Relation of the Engineer to Legislation." He referred to the American Institute of Electrical Engineers having been called upon for technical advice on water powers by Congress on several occasions; the effective work of the engineering societies in blocking dangerous license legislation at Albany in 1911; and finally activities that led up to the formation of the Engineering Council.

Nelson P. Lewis next spoke, on "The Relation of the Engineer to Administration." Positions requiring administrative ability, he observed, were once filled only by business men and lawyers, but in recent years the technically trained man is coming more and more into these positions. Commission form of government and the growing popularity of the city-manager idea has also opened a field for the engineer with executive ability. There are now 124 cities or towns in the United States that have city managers. The speaker was able to give particulars concerning eighty-eight of these and out of the eighty-eight the managers of fifty were professional engineers.

Spencer Miller, speaking for the mechanical engineers, was of the opinion that men of technical training are occupying positions of ever-increasing responsibility in public life; that public opinion, while not always right, is always autocratic; and that there is great opportunity for engineers as a class to help mold public opinion in the right direction. "Morale," said the speaker, "is as essential as technical training." Therefore the engineering societies should encourage the establishing of morale and should begin with a simple code of ethics, which should be rigidly enforced and which should be a requisite for admission to membership in the societies.

The last speaker on the program, Prof. Comfort A. Adams, prefaced his address by reference to engineering education, in which he emphasized that the subjects taught were secondary to how they were taught and by whom taught, and that this had great influence upon the success of the student in later life. Touching upon present economic conditions, he expressed the belief that there is too much destructive competition and pleaded for greater coöperation in the various industries.

Industrial Personnel Relations

On Mar. 24 the Chicago sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers and the Western Society of Engineers held a joint meeting at the rooms of the society last named. The attendance was the best of the season and the topic "Industrial Personnel Relations" one of particular interest at the present time. Introductory to the paper of the evening a moving picture, "The Outlaw," depicted to the audience the various causes of injuries to employees in industrial establishments and the methods employed to reduce the number of these accidents.

A. H. Young, manager of the Industrial Relations Department of the International Harvester Co., traced briefly the development of safety engineering and spoke of his former work with the Illinois Steel Co. along these lines. He said that the remarkable success of their efforts had really instigated the great safety movement of today, that accidental deaths of employees, ranging from 47 to 56 per year, had been reduced to 7 in 1913 and minor accidents in proportion; that through it all, including all expense attached to the safety movement, the company had been the gainer financially.

On the topic of the evening Mr. Young was intensely interesting. He compared the old haphazard methods of employing men with the centralized employment office, reviewing in particular methods used by his company. They now take three to three and one-half days to put men on the payroll as compared to three minutes in the old days. The employee is made to feel that he is a real part of the organization, hired to do the particular job for which he is best adapted. Moving pictures instruct him as to how the work is to be done. He is also instructed specifically by the foreman and is warned of the various dangers connected with the work. He is shown the best entrance to the plant for his department and is helped to find a home convenient to his work.

The threat of Bolshevism is due largely to not letting the men in on the "know." When the men fully understand the trade conditions in the field, the policy of the company and the reasons for doing certain things, the likelihood of a misunderstanding has been reduced.

An interesting experiment is the new arrangement the company is now making by which all matters of mutual interest are passed on by a works council, of which 50 per cent. are employees and the other half representatives of the employer, such as superintendents. This council determines the policy and the management carries it out. In this way the men are educated in the problems of management, they see and understand the difficulties, and have already shown signs of being fair and reasonable in the problems they have had a part in solving.

Progressive plans that have been adopted by Montgomery Ward and the Republic Flow Meters Co., were outlined in the discussion following the paper. Numerous other speakers indicated the interest that engineers are taking in one of the greatest world questions of the day.

Babbitt Metals and Solders[*]

By Alfred A. Greene

What is babbitt metal? You may be surprised to know that there is only one babbitt metal and that is the formula compounded by Isaac Babbitt about sixty years ago, for which Congress gave him a gold medal and $50,000. It is composed of 88.9 per cent. of tin, 3.7 per cent. of copper and 7.4 per cent. of antimony. The fact that he died in an insane asylum does not detract from the merits of his formula, because it has been the standard for high-grade antifriction metal for many years. All other lining alloys have been attempts to improve this formula in its physical characteristics or reduce its price. By custom these have been called babbitt metals, even though they contain no tin or copper, but, like No. 4 babbitt, consist of lead and antimony.

What are the physical characteristics of the elements that compose a lining alloy? Let us take genuine babbitt for our illustration. Tin is a crystalline metal, is very malleable and takes a high polish, but it would be too soft to use as a bearing. The addition of 7 per cent. of antimony makes it harder and gives it compressive strength, but also increases its brittleness, so copper must be added to give it toughness and tensile strength. The addition of 7 per cent. of antimony and 4 per cent. of copper to 89 per cent. of tin brings up the Brinell hardness to about 28 or over three times as hard as pure tin.

LEAD AS AN ANTIFRICTION METAL

Now, while tin and antimony are antifrictional, yet they are not the best antifrictional metals. Nature has given us lead, which is oily and greasy and is the best metal for antifrictional purposes; but unfortunately pure lead is very soft and by itself has no value as an antifriction metal. Unfortunately again, it is very hard to alloy other metals with lead. For instance, it is impossible to make a true alloy of lead and copper. I fully appreciate the claims that are made for the leaded bronzes, but I have yet to see an alloy of lead and copper, no matter how carefully made, that will stand remelting without segregation. This is because there is no affinity in the metals. On remelting this metal, the lead sweats out and settles to the bottom. This is what prevents its use as a lining alloy.

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[*] Abstract of an address made before the Purchasing Agents Association of St. Louis, Feb. 18.

Lining alloy manufacturers, recognizing the value of lead as an antifriction metal, have tried to use as much lead as they could, which has brought about a series of alloys ranging from 92 per cent. of tin and no lead, down to 95 per cent. of lead and no tin. It is a well known fact that a purchasing agent can always buy a babbitt metal at his own price. This can be readily understood when the prices of the metals are taken into consideration. With tin selling at 75c. a pound and lead at 5c. a pound, it is only necessary to take out 2 per cent. of tin and add 2 per cent. of lead to make a difference of 1½c. a pound, and it is almost impossible to tell from examination of the metal that it contains the 2 per cent. of lead. This may not work any harm from a service standpoint, because it is a fact that in the use of most of the lining alloys there is a great factor of safety, but it is not the proper way to do business.

Fundamental Requisites of a Bearing Metal

There are four fundamental requisites in a lining alloy: Compressive strength, tensile strength, heat resistance and antifrictional qualities. You will notice that I have placed antifrictional qualities last. It is generally understood that antifrictional qualities are the most important, but this is not so. A lining alloy to be of value must first have compressive strength; that is, it must be able to hold up the maximum load per square inch that is liable to be put on the bearings without squashing out. It must have sufficient tensile strength so that if the bearings are subjected to vibration or pounding it will not break apart. It must have sufficient heat resistance so that the alloy will stand the greatest possible heat before beginning to flow. Without these three qualities, the quality of antifriction has no great value. As a matter of fact, under ideal conditions the shaft never touches the babbitt metal. There is supposed to be a film of oil between the babbitt metal and the shaft all the time and this is what the shaft actually rides upon. It is when the oil film is not maintained that the antifrictional qualities of the metal become of real importance.

Genuine babbitt, which has been the standard for so many years as the best metal that could be produced for the most severe service, has certain physical characteristics. It is 28 Brinell hard, has an elastic limit of 10,000 lb. and a tensile strength of about 11,000 lb. Now, if the bearing-metal manufacturer can prove that it has the same physical characteristics, it really makes no difference to you from what the alloy is made, provided it is sold to you at an attractive price. Genuine babbitt contains 89 per cent. of tin and no lead; yet there is a concern in this country that has produced a metal which is the equal of genuine babbitt in tensile strength, compressive strength and Brinell hardness, has greater heat resistance and much better antifrictional qualities and yet it does not contain any tin, copper or antimony.

New Metal an Electrically Hardened Lead

It is an electrically hardened lead, with a very small percentage of other ingredients added, which have never before been used in babbitt metals. The process of manufacture takes several days to attain the desired result, and while the cost of manufacture is very much more expensive than any other babbitt, there still is an enormous saving when compared with tin-base alloys. The Bureau of Standards has made a series of tests and has issued a report showing that the metal has a tensile strength of 13,000 lb. and an elastic limit of 11,525 lb.; and in a running test on bearings at 1000 lb. per sq.in., load running at 400 r.p.m., the final temperature was only 150 deg. The following is a quotation from the report: "This metal possesses all the requisites of a good bearing; namely, hardness, compressive strength, low friction, heat resistance and low cost." This metal was born of necessity. Due to the war tin became very scarce and the Government requested that every effort be made to conserve it. As a result of scientific research work on original lines this metal was adopted.

The question is often asked if just as good babbitt metals can be made from scrap metals as from new metals. The answer is, good babbitt metals can be made from scrap metals; but it is not true that on exactly the same formula they are as good as they would be if made from new metals. The lining alloys made from scrap metals may do the work satisfactorily, because of the usual factor of safety, but although they are sold at a lower price they are not any cheaper. This is due to the fact that every time metals are melted a certain amount of oxidation takes place. If scrap metals are used, the oxides are present and in the ordinary shop practice they cannot all be eliminated. These oxides come to the top when the metal is melted and are skimmed off in the form of dross. This means that you do not get as many pounds of metal in your bearings when made from scrap as you would of the same formula made from new metals. Again, the physical structure of the metals is weakened when scrap metals are used. For instance, old lead pipe may contain lime, potash, sulphuric acid or any number of things. The impurities cannot be removed by just melting the lead in a pot. A chemical reaction has taken place in the lead, and it has lost its original characteristics. You cannot expect it to have the same strength as pure lead. If scrap tin is used, the same arguments apply as to lead. In the process of taking tin coating from tin cans, you are likely to get some iron oxide, and a small amount of iron will destroy a babbitt metal.

In regard to solders, practically the same arguments apply as in babbitt metals. We should be able to tell you the proper formula to use when you tell us what you want to do with the solder. We know that solder is made from tin and lead. Certain combinations produce certain results. As you cut down in tin and increase lead you raise the melting point and lose fluidity. Strange things happen in combinations of metals. For instance, tin melts at 450 deg. F. Lead melts at 628 deg. F. Theoretically, a mixture of 50 per cent. of tin and 50 per cent. of lead should melt at 540 deg. F. Actually, it melts at 398 deg., which is lower than the melting point of either of the metals that compose it. This means that with a 50-50 solder you get great fluidity at low temperatures. Therefore, a man can cover a greater surface in less time and use less solder than if he were compelled to use a solder which was more sluggish, and would have to change his irons more frequently, and could not make as thin a seam. A purchasing agent can save money on the cost of the solder by buying one that contains less tin, but if by so doing he increases the time of the job, and uses more pounds of solder, there is no real economy.

Blowing Down Water Columns

The low-water and high-water alarms on a good many of the water columns at the steam plants are operated by floats, designed to withstand a high static pressure.

Not only has the failure of these floats due to collapsing been the cause of a maintenance item of appreciable loss, but it has caused the boiler to be left without the protection of the water alarms from the time of the failure, which is in most cases shortly after the boiler is placed on the line, until the boiler is down for cleaning and repairs. So from a safety as well as a maintenance viewpoint steps should be taken to prevent the failure of these floats.

Floats will not fail if the water tender follows out the following instructions:

When blowing down water columns, observe the following precautions:

Open up the blowdown valve slowly. If there are two valves in this line, open the valve nearest the column—wide. Then open the second valve slowly.

Close the blowdown valve slowly. If there are two valves in this line, close the valve farthest from the column, slowly first, then close the remaining valve.

Under no conditions open and close the blowdown valves quickly for the purpose of causing the water in the glass to bob up and down. At times of low water, water tenders who operate their blowdown valves in this manner so as to determine approximately how low the water is, may cause a collapsed float.—*Au Sable News.*

Personals

William B. Symmes, Jr., solicitor of the United States Fuel Administration, has announced his resignation. His release was executed by Fuel Administrator Harry A. Garfield at Mr. Symmes' urgent request to be permitted to resume the practice of law in New York, where he is a member of the firm of Davis, Symmes & Schreiber.

F. R. Still, vice-president and secretary of the American Blower Co., has left on an extended trip for the Far East, where he will investigate trade conditions in connection with export work. Mr. Still's itinerary includes Japan, China, Australia and most of the European countries, and he expects to cover approximately 36,000 miles before returning home about Nov. 1.

Capt. A. C. Nell, who was in charge of the purchase of power and mechanical equipment in the construction division, U. S. A., for the period of the war, has been released and has been appointed Chicago district manager for the Lea-Courtenay Co and the Schütte & Koerting Co., with offices at 1466 Conway Building. Mr. Nell was formerly with the Allis-Chalmers Manufacturing Co.

Engineering Affairs

The Association of Iron and Steel Electrical Engineers, Philadelphia Section, will hold a meeting on Apr. 5. H. B. Vincent, operating engineering with Day & Zimmerman, Inc., will talk on "Power Transmission."

New York Engineers' Protective Society will give their next lecture, "Heating and Ventilating," in their Lodge Rooms, Hall No. 3, Bloomingdale Building, 60th St. and Third Ave., at 8 o'clock, Saturday evening. Apr. 5. These lectures are given for the education and entertainment of the younger members of the trade. All engineers are welcome whether members of the organization or not.

The Tenth Annual Engineers' Dinner of the American Society of Mechanical Engineers, American Institute of Electrical Engineers and the Boston Society of Civil Engineers will be held in Boston at the Boston City Club on Apr. 2. The following, as well as other societies, will participate: American Chemical Society, American Institute of Mining Engineers, American Society of Civil Engineers, Engineers' Club, Illuminating Engineering Society, New England Water Works Association, Plant Engineers' Club, American Society of Heating and Ventilating Engineers.

Miscellaneous News

The Compressed Gas Manufacturers' Association, Inc., has moved its offices from 120 Broadway to Rooms 1216, 1217, 23 E. 26th St., New York City.

Three Men Were Slightly Burned and others injured when the furnace of a Scott marine-type boiler failed in the basement of the Corbett Building, Portland, Ore., on the morning of Mar. 13. The boiler was oil fired, and the burning oil scattered by the explosion of the steam added to the seriousness of the accident.

The Engineering Advertisers' Association was organized recently at a meeting held at the LaSalle Hotel, Chicago. Some of the leading manufacturers of engineering products were represented, a constitution and by-laws adopted and officers and directors elected. Regular meetings of the association will be held monthly excepting during July and August, at which speakers of recognized prominence in the field of engineering advertising will give addresses, and free discussion will be given the various problems that arise in it.

National Association of Corporation Schools and the United Engineering Society, representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, will give employers and others interested in personnel work an opportunity to examine the methods developed by the Committee on Classification of Personnel in the Army at an exhibit to be shown on the third floor of the Engineering Societies Building, 29 West 39th St., New York City, April 1-12. The exhibit consists of a collection of wall charts, forms, photographs and models showing how the Army finds out what men can do best and how it uses that information; how soldiers are trade tested and how officers are rated and fitted into place; how the work is checked and supervised and its results in the war. It was on exhibition for several weeks at Washington, where it excited so much interest that in response to many requests the Adjutant General consented to its display in other cities. Two commissioned officers accompany the exhibit to explain its various features.

Business Items

The Archiable Electric Co., Inc., has been formed and is now doing business in electrical construction and wiring at 138 West Third St., Cincinnati, Ohio, with George W. Archiable as president and manager and W. E. Retsch as secretary and treasurer. Both men are well known to the trade in that territory.

The Chicago Pneumatic Tool Co. announces the following changes in its personnel: It has opened offices and warehouses at Tulsa, Okla. (313 Richards Building) and at El Dorado, Kan.; The Boston (Mass.) office of the company has been removed to 182 High St. with F. S. Eggleston, district manager of sales, representing the company's interests in this territory. J. I. Edwards has been appointed manager of the rock drill sales division, succeeding E. Eklund, who has been appointed special foreign representative and will leave shortly for Europe in the interests of the company; Fred H. Waldron, formerly Minneapolis representative of the company, has been appointed manager of the pneumatic tool sales division succeeding J. G. Osgood, resigned. Mr. Waldron's offices are now at the company's headquarters in the Fisher Building, Chicago; Nelson B. Gatch was recently appointed district manager of sales for the company at Minneapolis with offices at 301 Metropolitan Bank Building; J. K. Haigh has been appointed assistant district manager of sales for the company's San Francisco office at 175 First Street.

Trade Catalogs

Reilly Multiscreen Feed Water Filter and Grease Extractor. The Griscom-Russell Co., New York City. Bulletin 609. Fully describing this type of apparatus. Copy free upon request.

The Automatic Reclosing Circuit Breaker Co., of Columbus, Ohio, has issued Bulletin No. 301 describing its new types of breakers, "ARL," "DRL" and "CRL." A copy may be had upon application.

The Coatesville Boiler Works, of Coatesville, Penn., has issued a very instructive and attractive 96-page cloth-bound catalog, No. 24, on steel tanks, boilers and stacks, A. S. M. E. boiler specifications, stock sizes of A. S. M. E. return-tubular boilers, and other heavy steel-plate work.

The Quigley Furnace Specialties Co., Inc., New York City, has issued Bulletin No. 11, which describes the equipment employed in the Quigley system for preparing distributing and burning powdered fuels. It describes a method which has been in successful operation for many months on a variety of furnaces and was developed as the result of 20 years' practical experience in selection and application of fuels and in furnace design and operation.

The Westinghouse Electric and Manufacturing Co., of East Pittsburgh, Penn., has issued a complete catalog in which all of its electrical supplies are listed. Every effort was exercised to make the catalog of the greatest convenience to purchasers. It is made up of 1264 pages of description pertaining to the products of the company and a score of other pages containing a complete cross index, an index to style numbers, and a table of "Approximate Cost Multipliers" which enables one to figure the approximate cost of all supplies listed. The book is more than a catalog in that it contains much information of a technical and engineering nature. Practical suggestions for the use of many kinds of apparatus for the transmission and utilization of electric power are given. It is planned to issue this catalog annually.

New Construction

PROPOSED WORK

R. I., Westerly—The city approved $300,000 bond issue to purchase or construct a lighting plant. E. E. Whipple, City Clk.

Conn., New Haven—A. L. and I. Adelman, 10 Garden St., will install a steam heating plant in the 5-story apartment hotel which it plans to build on Whalley Ave. Total estimated cost, $165,000. J. Weinstein, 6 Church St., Arch.

Conn., Stratford—The Raybestos Co., Bostwick Ave., Bridgeport, will install a steam heating plant in the 1-story, 160 x 170 ft. factory which it plans to build on East Main St. Total estimated cost, $100,000.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., New York City, will install a steam heating plant in the 4-story, 100 x 144 ft. P. S. No. 100 which it plans to build on West 1st St. Total estimated cost, $299,500. C. B. J. Snyder, Municipal Bldg., New York City, Arch.

N. Y., Lyons—The Lyons Cold Storage Co. will install artificial ice making machinery in their Rankert plant to make 15 tons of ice daily. Estimated cost, $12,000.

N. Y., New York—The Italian Savings Bank, Cleveland Place and Spring St., will install a steam heating plant in the 10-story, 100 x 150 ft. bank which it plans to build. Total estimated cost, $150,000. C. P. H. Gilbert, 1123 Bway., Arch.

N. Y., New York—Musher & Co., 140 Liberty St., will install a steam heating plant in the 12-story, 49 x 100 ft. store and loft building which it plans to build at 255-257 5th Ave. Total estimated cost, $190,000. S. B. Eisendrath, 18 East 41st St., Arch.

Md., Middletown—The Middletown Packing Co. is in the market for boilers, pumps, shafting, pulleys and electric motors, to be installed in the factory and warehouse which it plans to build. Total estimated cost, between $6500 and $7000.

Md., Sollers Station (Sollers P. O.)—The Aluminum Ore Products Co., Inc., 800 Maryland Trust Bldg., Baltimore, plans to enlarge its plant here. Project includes boiler house equipped with cross-drum and marine type boilers, automatic stokers, mechanical blowers, etc., and power house with four 1000 kw. steam engines and generators. Estimated cost, $8,000,000. J. E. Aldred, Chn. Bd. Dirs., Consolidated Gas, Electric Light & Power Co., Baltimore, interested.

Va., Front Royal—The Virginia Orchard Co. plans to build a cold storage room. Estimated cost, $13,000.

Ohio, Akron—The McNeil Boiler Co., Crosier and Sweitzer Sts., is in the market for a 300 to 1000-ton steam hydraulic forging press.

Ohio, Cleveland—The Accurate Machine Co., 1011 Power Bldg., has awarded the contract for the construction of a 2-story, 40 x 160 x 180 ft. factory and office building on East 134th St. and Court Rd., to the Hunkin Conkey Co., 601 Century Bldg. A steam heating plant will be installed in same. Total estimated cost, $250,000.

Ohio, Cleveland—The Board of Education, East 6th St. and Rockwell Ave., will install a steam heating plant in the 1-story school which it plans to build on Miles Ave. Total estimated cost, $100,000. W. R. McCornack, East 6th St. and Rockwell Ave., Arch.

Ohio, Cleveland—The Ohio Forge Co., 2186 East 65th St., is in the market for a 10,000-lb. double frame steam hammer.

Ind., Bloomington—J. Hoadley & Sons, Co., Inc., is in the market for a 125 hp. boiler, 100 lb. pressure.

Mich., Flint—The National Bank of Flint and the Genessee Co. Savings Bank will install steam heating equipment in the 10 story, 44 x 120 ft. bank and office building which it plans to build on Kearsley and Saginaw St. Hoggson Bros., 485 5th Ave., New York City, Arch.

Mich., Harbor Beach—The city plans to install pumps, in connection with sewer improvements. B. W. Jenks, Mayor.

Mich., Pontiac—The Board of Education will install a low pressure heating plant in the 1-story, 110 x 200 ft. grade school which it plans to build. Total estimated cost, $100,000. Perkins, Fellows & Hamilton, 814 Tower St., Chicago, Ill., Archs.

Ill., Chicago—The [illegible] Drop Forge Co. is in the market for [illegible] steam hammer, a [illegible] drop, [illegible] d.c. motor.

Ill., Chicago—The Independence State Bank, [illegible] South Kedzie Ave., will install a [illegible] heating plant in the [illegible] story [illegible] ft. bank and office building which it plans to build on [illegible] St. and Kedzie Ave. Total estimated cost, $125,000. H. L. Newhouse, 1653 Prairie Ave., Arch.

Ill., Chicago—A. F. Whitlock, c/o W. W. Whitlock, Archt., 111 West Washington St., will install a high pressure steam heating plant in the [illegible]-story [illegible] x 150 ft. theater and stores which he plans to build on West [illegible] St. and Union Ave. Total estimated cost, $400,000.

Wis., Beaver Dam—The Weyenberg Shoe Co. plans to build a power house and factory. Estimated cost, $150,000. H. J. Esser, 82 Wisconsin St., Milwaukee, Engr.

Wis., Green Bay—C. Hartmann Co. will install 12 direct connected centrifugal pumps, [illegible] gal. capacity with alternating current motors, 16 direct connected capstans with a.c. motors, in the 80 x 600 ft. floating dry dock which it plans to build. Total estimated cost, $500,000. Morrison & Beck, 140 South Dearborn St., Chicago, Ill., Engr.

Wis., Sheboygan—The Standard Oil Co., 1209 Pennsylvania Ave., plans to build a filling station and is in the market for 4 best grade gasoline pumps, lighting arrangement and safety apparatus. Total estimated cost, $3000. R. R. John, Engr.

Minn., Bovey—The Board of Education will install steam heating and mechanical ventilating systems in the 3-story, 84 x 140 ft. grade school which it plans to build. Total estimated cost, $150,000. J. V. Coleraine, Secy. Bd. Educ. W. T. Bray, Fidelity Bldg., Duluth, Minn., Arch.

Kan., Kansas City—The city will soon receive bids for furnishing a 5000 kw. generator, turbine driven, 2400 volt, 60 cycle, 3 phase, at 3600 rev., temp. raise 50 degrees C. 170 lb. steam pressure. J. D. Donovan, 1132 Cleveland Ave., Ch. Engr.

Neb., Lincoln—The city will soon award the contract for a 400 hp. Diesel oil engine and generator. A. Dobson, City Engr.

Neb., Omaha—The Skinner Packing Co., 904 1st National Bank Bldg., plans to build an 8-story, 99 x 132 ft. cold storage plant on 12th and Douglas St. Estimated cost, $500,000. H. C. Christianson, 7258 Union Ave., Chicago, Engr.

N. D., Lakota—The city will soon award the contract for constructing 2 concrete wells, 2 motor driven pumps, 2 pump houses, 1 electric transmission line, 1 heating system for elevated tank, two 3 in. motors, etc. E. A. Hughes, City Aud.

N. D., Lisbon—The Lisbon Electric Light Co. plans to improve and equip its plant. Estimated cost, $15,000. H. H. Weeden, Supt.

Mont., Glendive—The State Public Utilities Commission has ordered the Eastern Montana Light & Power Co. to install meters on all services using more than 120 kw.

Mont., Wibaux—The Eastern Montana Light & Power Co. plans to improve and build additions to its plant to supply Wibaux and Glendive, also Beach, N. D. H. Kopf, Mgr.

Ark., Helena—The Helena Gas and Electric Co. plans to build an electric light plant. H. P. Roth, Mgr.

Okla., Perry—The city plans to improve the electric light plant and water-works system. Estimated cost, $100,000.

Utah, Bingham—The city voted $15,000 bond issue for extending and overhauling the electric distribution system, including new street lighting equipment. C. O. Roskelly, Engr.

Ore., Klamath—The California-Oregon Power Co., 131 Leidesdorff St., San Francisco, Cal., plans to build a dam across the Link River in connection with the [illegible] power plant at Copco, Cal. G. J. Warren, Klamath Falls, Div. Supt.

Cal., Glendale—The city is having plans prepared by H. E. Lanch, Engr., [illegible] Central Bldg., Los Angeles, for the construction of power and electric generating plants in connection with waterworks improvements. Total estimated cost, $[illegible]. Bonds must be voted and shares purchased in Verdugo Canyon Water Supply Co. J. C. Sherer, City Clk.

Cal., Independence—The Board of Public Service, Los Angeles, entered into contract with the Big Pine Water Users Assn. Inc. Co. whereby city acquires [illegible] reservoir sites and sites for 3 power plants (construction will not be undertaken for some time). W. Mulholland, 645 South Olive St., Ch. Engr.

Cal., Inglewood—The city plans election soon to vote on $217,000 bond issue for the construction of a waterworks system. Plans include the installation of wells, pumps, stand pipe, reservoir and distributing system or the purchase of pumping plant and distributing system of the Inglewood Water Co. and extensions and improvements to same. Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, Engrs.

Cal., Los Angeles—The Bonnie Reed Film Manufacturing Co., Niles, plans to build a motion picture plant on Sunset Blvd. and Bronson Ave. Plans include the construction of a power house, laboratories, offices, etc. Total estimated cost, $1,000,000. Train & Williams, 225 Exchange Bldg., Arch.

Que., Quebec—The Harbor Commissioners, Pointe a Carcy, plans to build a cold storage plant. Estimated cost, $1,000,000. St. G. Boswell, c/o Harbor Comrs., Engr.

Ont., London—The Holeproof Hosiery Co., 186 King St., will install a steam heating plant in the 4-story, 150 x 200 ft. hosiery factory which it plans to build on Bathurst St. Total estimated cost, $250,000.

Ont., Parry Sound—The city is having plans prepared by G. Murray, Engr., Parry Sound, for the construction of an electrical plant. Estimated cost, $125,000.

Ont., Port Arthur—The Ontario Hydro-Electric Commission, Toronto, plans to build a 1-story, 100 x 250 ft. power plant with 50,000 hp. capacity on the Nipigon River, Cameron Falls, near here. Work will be done by day labor. Noted Mar. 18.

CONTRACTS AWARDED

R. I., Providence—The U. S. Furnishing Co., Charles St., has awarded the contract for the construction of a 2 story, 40 x 55 ft. addition to its power house, to Day & Zimmerman, 611 Chestnut St., Philadelphia, Penn. Estimated cost, $35,000.

Conn., Plainville—Landers, Frary & Clark, Commercial St., New Britain, has awarded the contract for the construction of a 40 x 40 ft. boiler house on Woodford Ave., to the Torrington Building Co., 197 Water St., Torrington. Estimated cost, $20,000.

Fla., Jacksonville—The Ward Engineering & Battery Co., 239 13th St., Miami, has awarded the contract for the construction of a 1 story, 50 x 105 ft. battery station on Forsythe St., to O. P. Woodcock, 403 Main St. Estimated cost, $10,000.

N. Y., New York—The National Ice & Coal Co., 103 Park Ave., has awarded the contract for the construction of a 2-story, 120 x 120 ft. refrigerating plant at 8-10 Tompkins St., to J. Brody, 8-10 Tompkins St. Estimated cost, $75,000.

Neb., Sterling—The city has awarded the contract for the construction of a transmission line from Sterling to Tecumseh, to the Martz Construction Co., Seward. Estimated cost, $4681. E. H. Johnson, City Clk.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Cir
Egg	$7 80@7 9
Stove	7 95@8 1
Chestnut	8 05@8 3

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net ton	$2 15@2 75	$2 80@3 5
F.o.b. Philadelphia, gross ton	4 20@4 90	5 00@5 5
F.o.b. New York, gross ton	4 50@5 25	5 35@5 9
Alongside Boston (water coal), gross ton	6 10@6 85	6 90@7 8

Pocahontas and New River are quoted at $4 70@5 25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7 20@8 60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5 95	$7 80	Pea	4 80	6 55
Egg	5 85	7.70	Buckwheat	3 40	5 15
Stove	6 10	7 95	Rice	2 75	4 50
Chestnut...	6.20	8.05	Barley	2 25	4 00

Bituminous

	Spot	Contract
South Forks	$2 90 @ $3 50	$2 95 @ $ 5
Cambria County (good grades)	2 80 @ 3 10	2 95 @ 3 1
Clearfield County...	2.65 @ 2 95	
Reynoldsville	2 65 @ 2 95	2 85 @ 3 0
Quemahoning	2 85 @ 3 10	2 95 @ 3 1
Somerset County (best grades)	2 80 @ 2 95	2 95 @ 3 1
Somerset County (poorer grades) ..	2 50 @ 2 75	2 75 @ 2 9
Western Maryland..	2 50 @ 2 75	2 65 @ 2 8
Fairmont	2 10 @ 2 35	2 35 @ 2 5
Latrobe	2 25 @ 2 40	
Greensburg	2 35 @ 2 40	2 35 @ 2 6
Westmoreland	2 60 @ 2.75	2 65 @ 2 7
Westmoreland run-of-mine..........	2.40 @ 2 65	2 40 @ 2 6

Quotations at the upper ports for both bituminous and anthracite are 5c higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Por Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken.....	$5.95	$7.80	Buckwheat....	$3 40	$4.4
Egg	5 85	7 70	Rice	2 90	3 8
Stove...	6 10	7 95	Boiler	2 70	3 7
Nut	6 20	8 05	Barley	2 40	3 3
Pea .	4 80	6 40	Culm	1 25	2 1

CHICAGO—Current prices per ton for Illinoi and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mine
Prepared sizes	$2 75	$3 25
Mine-run.............	2.35@ $2 50	3 00
Screenings	1 85@ 2 20	2 75

BIRMINGHAM—Current prices per net ton f.o.b mines are as follows:

	Mine-Run	Prepared	Slack an Screening
Big seam.	$2 45	$2 75	$2 40
Black Creek and Cahaba......	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith.....	....	5.25	

Domestic quoations, slightly increased, are a follows:

	Lump and Nu
Black Creek and Cahaba .	3 85@$4 5
Corona	3 65
Jagger..........................	3.50
Montvallo ..	5 00

ST. LOUIS—The prevailing circular per net to f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2 75	..	....
Williamson County			
Prepared sizes, lump, egg, nut ...	$2 55	$2 55	$1 90@ 2
Mine-run	2.20	2.20	1.60@ 1
Screenings..........	2.05	2.05	.95@ 1.
3-in. lump..........	....	2.30	
2-in. lump..........	....	....	1 75@ 1

Williamson-Franklin rate to St Louis is $1 other rates 92½c.

PRICES - MATERIALS - SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft. Lengths
Underwriters' 2½-in	75c. per ft.
Common, 2½-in	30%

Air	First Grade	Second Grade	Third Grade
¾-in. per ft	$0 55	$0 40	$0.30

Steam—Discounts from List

First grade...... 25%   Second grade......35%   Third grade. . 40%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition ... 50%   Best grade 30%
Standard ... 40%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	30%	35%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1 20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0 27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	60
3-in.	.45	2½-in.	.75
8-in.	1 10	3 -in.	90
10-in.	1.30	3½-in.	1 05

85% magnesia high pressure		List
For low-pressure heating and return lines	4-ply	58% off
	3-ply	60% off
	2-ply	62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5¼	7.2	8½	14½
Fiber or sponge	8	10	6	13	9	18
Transmission	7	9	6	13	9	20
Axle	4½	6	4	4.75	3½ to 4½	5¼
Gear	4½	9	4½	7.5	7½	8
Car journal	22(gal.)	21 (gal.)	3½	4.9	9¾	8

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	11.00 to 13 00	13 00	16 50	12.00 to 16 50
Colored mixed	8.50 to 12.00	12.00	13.00	11.50 to 14.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13¼ x 13¼	13¼ x 20½
Cleveland	$52.00	$58.00
Chicago	48.00	50.00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw in barrels	$1.55	$1.55	$1.68	$1.65	$1 66	$1.65
5-gal. cans	1.70	1.65	1.85	1.80	1.86	1.75

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13 00	14 50	11.25	11 50	13 00	10 50
25- and 50-lb. kegs	13.25	14.75	11.50	11.75	13.25	10 75
12½-lb. keg	13.50	15.00	11.75	11.00	13 50	11.00
1-lb. cans	15.00	16.50	13.25	13 00	15 00	13 00
5-lb. cans	16.00	17.50	13 25	13 50	16 00	13 00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. car boys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel 7/16 and smaller	45%	55%	50%
Tinned	35%	55%	45%

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$6.37 Cleveland...$5 00 Chicago...$5.47 Pittsburgh... 4 65

Coneheads, same sizes:

New York....$6.25 Cleveland...$5.10 Chicago $5.57 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00	at Chester, Penn.
Chrome cement	net ton	65.00	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48	at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50–35.50	at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90	at Chester, Penn.
Silica brick	net ton	45–55	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $50; silica, $50; magnesite, $110; chrome, $165.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL — Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	90.00	77 00	93.00	75.00	90 00
Commercial	42 00	50.00	18 50	30.00	15 00	30.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.00
Chicago	16.50	15 00

In coils an advance of 50c. usually is charged.
Note—Stock very scarce generally

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft	7.65	6.85	6 10	6 85
7 in. by 35 ft	11.10	10 00	8.95	10 00
8 in. by 35 ft	12 65	11.35	10 10	11.35
7 in. by 40 ft	12.85	11 50	10 20	11 50
8 in. by 45 ft	18.90	16 90	15 00	16 90
8 in. by 50 ft	22.65	20.30	18 00	20 30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft	$9.00
12-in. butts, 6-in. tops, length 30-40 ft	11.50
12-in. butts, 6-in. tops, length 41-50 ft	12.50
14-in. butts, 6-in. tops, length 51-60 ft	21.00
14-in. butts, 6-in. tops, length 61-71 ft	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

	Steel			Iron	
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼, and ⅜	50½%	24%	¾ to 1½	39½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

2	50½%	38%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	46½%	29%	¾ to 1½	39½%	24½%
½	51½%	39%			
¾ to 1½	55½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48%	37½%	2	33½%	20½%
2½ to 4	51%	40½%	2½ to 4	35½%	23½%
4½ to 6	50%	39½%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel-butt-welded	47%	31%	46½%	31%	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	42½%	27½%	51½%	41%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%. Cast iron, standard sizes, 10% off.

Note—Recent pig-iron reduction will lower price of steel pipe. New discounts will be given next month.

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in	40½	3½ to 4½ in	15½
2½ to 3¼ in	30½	3 to 3¼ in	1
2¼ in	24	2¾ to 2¾ in	+ 1
1¾ to 2 in	19½	2 to 2¼ in	+ 16
		1¾ to 1¾ in	+ 29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in	$327	1¾ in	$207
1¼ in	267	2 to 2¼ in	177
1½ in	257	2½ to 3¼ in	167
1¾ in	207	4 in	187
		4½ to 5 in	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE

B & S Size	Two Cond M Ft	Three Cond. M Ft	Two Cond. Lead M Ft	Three Cond. Lead M Ft.
No 14 solid	$104 00	$138 00	$164 00	$222 00
No. 12 solid	135 00	170 00	211 00	290 00
No. 10 solid	185 00	235 00	255 00	325 00
No. 8 stranded	235 00	325.00	345 00	450 00
No. 6 stranded	370 00	472 00	625.00	

From the above lists discounts are:

Less than coil lots	Net List
Coils to 1,000 ft	10%
1,000 ft and over	15%

BATTERIES, DRY—Regular No 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0 40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
¼			$18 24	$19 38	$5 76	$6 12
½	$76 50	$81 60	18 24	19 38	6 72	7.14
¾	101 20	108 10	24 00	25 50	9 60	10 20
1	149 60	159 80	35.52	37 74	12 48	13 26
1¼	202 40	216 20	45 45	48 15	17 17	18 19
1½	242 00	258 50	60 60	64 20	21.21	22 47
2	325 60	347 80	111 11	117 70	28 28	29 96
2½	514 80	549 90	181 80	192 60	40 40	42 80
3	673 20	719 10	484 80	513 60	60 60	64 20
3½	837 20	892 40	1,070 60	1,134 20	80 80	85 60
4	1,013 70	1,079.10	1,237.25	1,310 75	101 00	107.00

5% cash 10 days

From New York Warehouse—Less 5% cash

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
7/32	250	$0 05½	Coils 55% Off. Less coils, 40% off
¼	250	.06	
⅜	250	.09	
½	200	.12	
⅝	200	.15	
¾	150	.18	
1	100	.25	
1¼	100	33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B	$0 24
D. P M L	.18	T. P. to D. P. T. B	38
T. P. M. L.	26	T. P. S. B.	33
D. P. S. B.	19	T. P. D. B.	54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp
D. P M L	$0.33	$0 84	$1 68
T. P. M. L.	.48	1 20	2 40
D. P S B	.42	1.05	
T. P. S. B.	.81	1.80	
D. P. D. B.	.78	2 10	
T. P. D. B.	1.35	3.60	
T. P. to D. P. D. B.	.90	2.52	

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$22 00
No. 16 cotton twisted	28 40
No. 18 cotton parallel	25 00
No. 16 cotton parallel	32 00
No. 18 cotton reinforced heavy	35 00
No. 16 cotton reinforced heavy	42 00
No. 18 cotton reinforced light	30 00
No 16 cotton reinforced light	36 00
No. 18 cotton Canvasite cord	29 00
No. 16 cotton Canvasite cord	35 00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp	100	$0 25
35-amp. to 60-amp	100	.35
65-amp to 100-amp	50	90
10-amp. to 200-amp	25	2 00
225-amp. to 400-amp	25	3 60
450-amp. to 600-amp	10	5 50

600-Volt	Std Pkg	List
3-amp to 30-amp	100	.40
35-amp to 60-amp	100	.60
65 amp to 100 amp	50	1 50
110-amp to 200-amp	25	2 50
225-amp to 400-amp	25	5 50
450-amp to 600-amp	10	8 00
Discount Less 1-5th standard package	30%	
1-5th to standard package	40%	
Standard package	52%	

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$5 25 C
0-30 ampere, less than standard package	7 00 C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B Watts	Plain	Frosted	No. in Package	Mazda C Watts	Clear	Frosted	No. in Package
10	$0 35	$0 38	100	75	$0 70	$0 75	50
15	35	38	100	100	1 10	1 15	24
25	35	38	100	150	1 65	1 70	24
40	35	38	100	200	2 20	2 27	24
50	35	38	100	300	3 25	3 35	24
60	40	45	100	400	4 30	4 45	12
100	85	92	24	500	4 70	4 85	12
				750	6 50	6 75	8
				1000	7 50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

		Each
Hubbell, porcelain No. 5406,	standard package 250	$0.24
Hubbell composition No. 5467,	standard package 50	.32
Benjamin swivel No. 903,	standard package 250	20
Hubbell current taps No. 5638,	standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12 00	$14 00	$13 90	$25.00
12	13 25	15 70	18 05	30 70
10	18.30	21 00	23 85	41 50
8	25.54	28 60	32 70	56 77
6			51 40	
4			70 00	
2			101 80	
1			131 86	
0			160 00	
00			193 50	
000			235 20	
0000			288 60	

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$11 00	$14.50	$30 40	$21.00	$16 00	$33 00	$10 95	$15.25	$27.75
10	19 20	25 70	49 00	27 20	31 00	69 00	20 25	24.25	46.90
8	26 95	34 25	67 00	38 00	42 00	78 00	27 60	32.60	
6	43 90	46 20			65 00	130 00	48 25	54.75	
4	62 35	65 15			93 00		66 90	73.75	
2	92 60	96 25			140 00		96.00	104.50	
1	120 95	125 20			182 00		121.00	136.40	
0	164 80	164 80			242 00		169.00	174.60	
00		203 35			290 00		203 50	214.00	
000		248 40			360 00		246.00	257.50	
0000		302 55			435 00		295.50	358.50	

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap.			⅜ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0 66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	45c. lb.
No. 18 B.&S. regular 1-lb. coils	47c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0 42	$0.68	$1.02	$1.36
60	74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2 70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

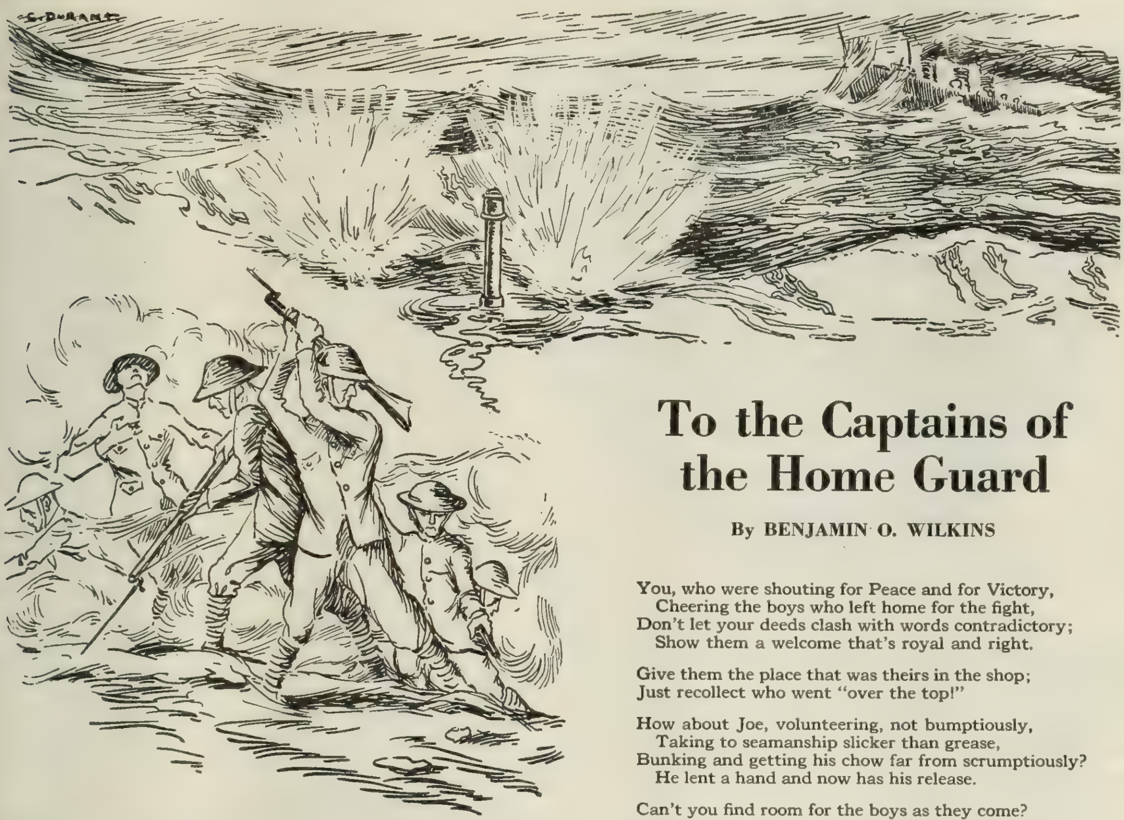
Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10 14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	− 8%
$25 to $50 list value	−15%
$50 to $200 list value	−20%
$200 list value or over	−25%

POWER

Volume 49 New York, April 8, 1919 Number 14



To the Captains of the Home Guard

By BENJAMIN O. WILKINS

You, who were shouting for Peace and for Victory,
  Cheering the boys who left home for the fight,
Don't let your deeds clash with words contradictory;
  Show them a welcome that's royal and right.

Give them the place that was theirs in the shop;
Just recollect who went "over the top!"

How about Joe, volunteering, not bumptiously,
  Taking to seamanship slicker than grease,
Bunking and getting his chow far from scrumptiously?
  He lent a hand and now has his release.

Can't you find room for the boys as they come?
Going, your plaudits outsounded the drum.

There's that lad Tom, who enlisted so grittily,
  Backed his convictions by going across,
Smothered a sob while he said "good-by" wittily—
  He deserves work again. Were you his boss?

Show what your patriotism can do.
All that you've hoped for is now coming true.

Prove to the world by your whole-hearted readiness
  What you will do for the men who have shown
How a firm faith, joined with courage and steadiness,
  Conquered the tyrant who praised Might alone.

Welcome the men who faced death without fear;
Lend them a strong, helping hand while you cheer.

Many there are who will trudge along shabbily,
  Hungrily seeking the work that they need.
Don't look askance at them—don't treat them crabbily.
  Welcome them—back up the will with the deed!

If you could not *go across* as a "gob,"
Now is your chance—*come across* with a job!

NEW BOILER PLANT *of the* A. S. & R. CO. *at Omaha,*

By

*R. N. Robertson**

Underfeed stoker plant burning Iowa coal at high maintained efficiencies and with a minimum of operating troubles. Two boilers, interconnected and placed in one setting, are baffled to fully utilize the radiant energy from the fire, and for the same reason the superheater is placed behind the brige-wall. Large furnace volume is provided. The construction in the walls of the setting is unusual. General features of the plant are simplicity, low initial cost, accessibility and minimum labor requirements.

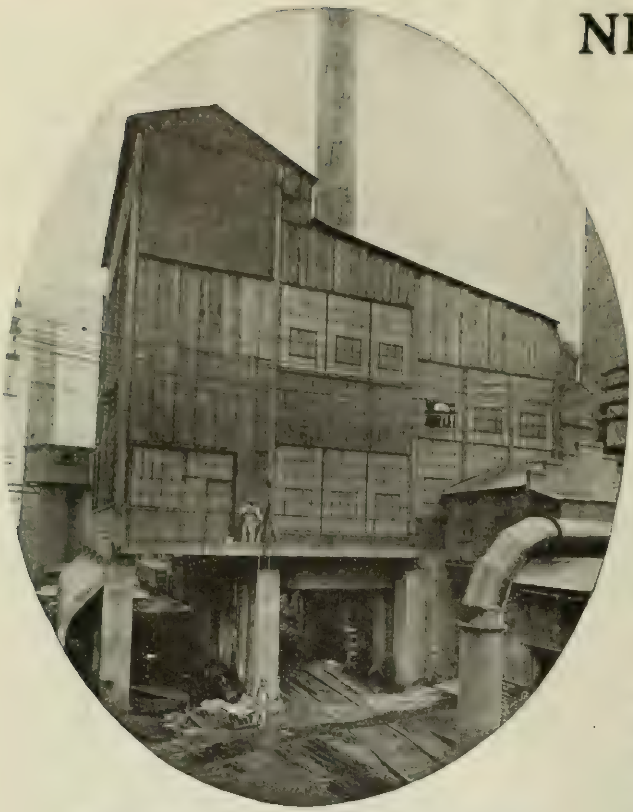


FIG. 1. EXTERIOR OF THE NEW A. S. & R. CO. BOILER PLANT AT OMAHA

EARLY in 1916 the increasing demands for power and for steam for process work made it apparent that additional boiler capacity would shortly be needed at the Omaha Plant of the American Smelting and Refining Co. Because of threatened shortage of labor and the lack of avilable ground space, only two courses seemed to be open—to remodel the old boiler plant into a relatively modern one or to install a new and thoroughly up-to-date plant designed for high operating capacity. After a careful study of conditions it was decided to install the first unit of a four-unit new boiler plant to relieve the immediate acute demand for steam.

In the design of this plant the following considerations were used as a basis and all details were worked out in consonance with them:

1. The demand for steam is continuous 24 hours per day, 365 days per year.

2. The labor required for coal and ash handling and the operation of the plant must be a minimum.

3. The mechanical equipment for handling the coal and ash must be of the simplest mechanical nature consistent with the service to be rendered.

4. All equipment must be of such character as to render repair and replacement easy, simple and cheap, and as far as possible must be of such character and so installed as to render running repairs possible Consequently, it must be readily accessible at all times and under all conditions.

5. The capacity obtainable from the boilers and the other equipment should be a maximum on account of the limited ground space available for future extensions.

6. The design of the plant should be such that new units can be added at any time without the necessity for making any except minor changes in arrangement

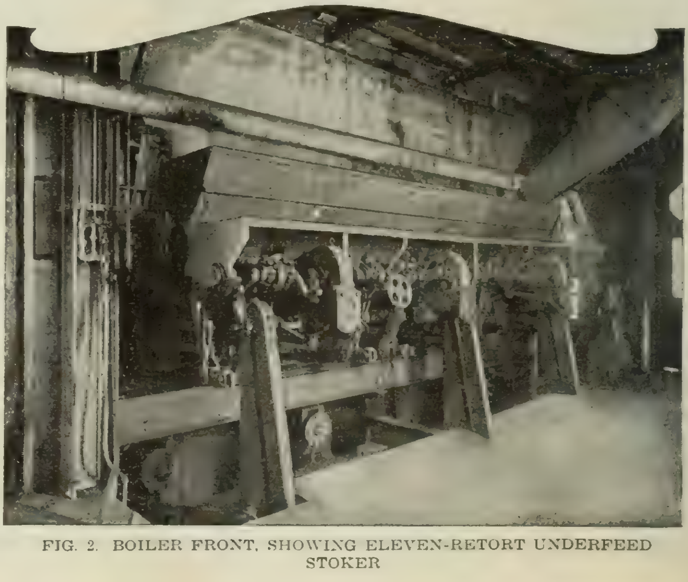


FIG. 2. BOILER FRONT, SHOWING ELEVEN-RETORT UNDERFEED STOKER

to meet the requirements of the most modern equipment at the time the new units are installed.

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*Chief engineer, American Smelting and Refining Company.

Figs. 1 and 3 show the arrangement finally decided upon as most nearly fulfilling the requirements previously set forth. It will be seen that no basement has been provided, the first floor resting on concrete columns, so that coal and ash cars can pass underneath. The building itself is of simple, cheap construction, providing plenty of light and ventilation. The plant is without frills of any kind, and all expenditures were considered from the viewpoints of reliability, economy and accessibility.

The fuel available, and on which the designs of the boilers, furnace and the setting were based, is Iowa steam coal running about 14 per cent. moisture, 31 per cent. volatile matter, 35 per cent. fixed carbon and 20 per cent. ash as fired. This coal has a heat value of about 9000 B.t.u. and a sulphur content of about 6 per cent. as fired. The ash from this fuel forms large, sticky and in some cases fluid clinkers, extremely hard to handle, very tough when hot and of a stony hardness when cold. This condition, coupled with the necessity for obtaining high continuous capacity and economy, led to the decision to install inclined underfeed stokers of large retort capacity per boiler horsepower of rating, so that high capacity could be obtained with moderate rates of combustion.

The major equipment of the new boiler plant consists of two 406-hp. water-tube boilers, interconnected, provided with steam purifiers and set over one 11-retort 17-tuyereplate inclined underfeed stoker, Fig. 2, equipped with steam-operated power ash-dump plates and a vertical engine on the first floor for driving. The superheater contains approximately 100 sq.ft. of surface. The forced-blast fan is geared to a 65-hp. steam turbine, controlled by a compensated damper regulator for varying the speed of the fan to meet the steam requirements. A 6-ton monorail crane fitted with a $1\frac{3}{4}$-yd. clamshell bucket transfers the coal from the railroad cars to the overhead bunker. On its way to the stoker the coal is weighed by a manually operated traveling-hopper coal scale.

The instrument equipment for the boiler room consists of an indicating, recording and integrating steam-flow meter; a continuous recording throttling steam calorimeter between the boilers and the superheater; recording thermometers on the superheater, stack and feed water; recording steam-pressure gage, a recording water-level gage, a recording CO_2 meter, a revolution counter for the stoker plungers, a recording gage for the blast pressure in the windbox, indicating draft gages for observing the stack and the furnace drafts and permanent weighing tanks for boiler testing. The unit is also provided with a nonreturn stop valve in the steam line, graduated feed type of feed-water regulator in duplicate, the usual equipment of pop safety valves and manually operated blowoff and feed-water valves.

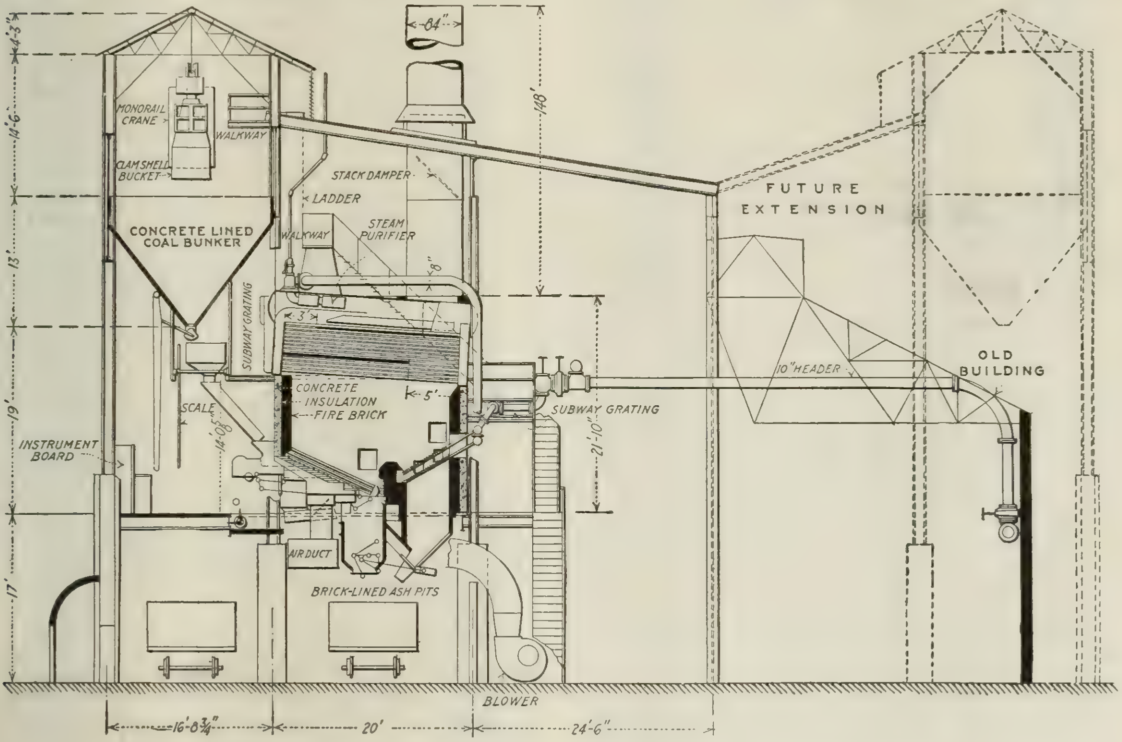


FIG. 3. SECTIONAL ELEVATION OF THE BOILER ROOM AT THE OMAHA PLANT

It will be seen that the equipment installed is standard in every respect. The arrangement and the proportions of the installation are, however, rather unusual, but have proved their value in operation.

The designer of this plant believed that the development of the inclined underfeed stoker must necessarily soon cause a decided change in the general standard of boiler units, tending toward larger areas exposed to the radiant energy of the furnace and comparatively smaller tube areas exposed to the gases of completed combustion, and that for this class of service large furnace areas and combustion volumes were essential to economy and capacity. For example, it was believed that a horizontal water-tube boiler consisting of 462 tubes arranged 33 wide and 14 high and horizontally baffled to expose the lower three rows of tubes to the radiant energy of the fire would give better capacity and economy than would the same boiler arranged 22 wide and 21 high, and vertically baffled to expose only one-half the bottom row of tubes to the radiant energy of the fire.

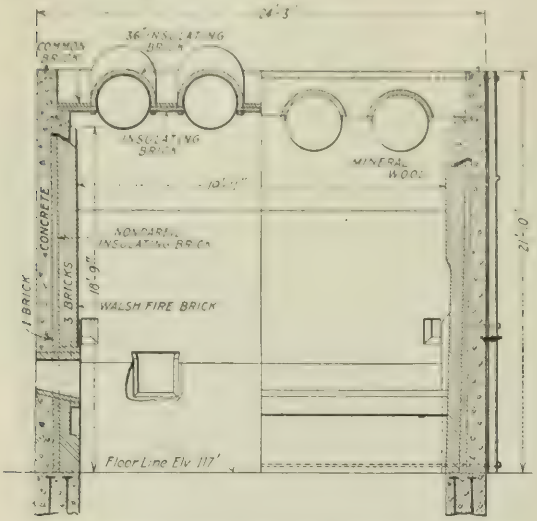


FIG. 4. TRANSVERSE SECTION THROUGH SETTING

The former arrangement was used in this case and produced a furnace 19 ft. 6 in. wide, 14 ft. high from the boiler-room floor to the bottom of the front water-leg and 9 ft. 6 in. from the front wall of the boiler to the low bridge-wall, which was originally built 2 ft. high with 7-ft. flame space over it, but later increased in height to 3 ft. 6 in. in order to shadow the superheater a little and thus reduce the superheat. The baffle tiles were originally installed on the third row of tubes from the bottom, but were later moved to the fifth row of tubes after refiguring the gas velocities through the boiler.

Experience in the old boiler room indicated that much trouble might be expected from clinker adhesions to the bridge and side walls of the furnace. To provide against this, waterbacks were installed along both side walls and across the bridge-wall. They have prevented trouble from clinker adhesions to either the side walls or the bridge-wall. The water from these waterbacks goes to a softener and comprises the greater part of the makeup required for the boiler feed. It seems probable that the number of pipes in the bridge-wall waterback might safely be reduced to two or possibly to one with a reduction in the amount of water required for cooling.

This plant has frequently handled successfully and disposed of clinkers 4 ft. square and 18 in. thick without difficulty and without unusual effort on the part of the fireroom attendants. Frequently, also, coal has been burned that produced liquid ash that ran through the dump plates in streams. This condition neither reduced the capacity of the plant nor added to the labor of the fireman.

The unit is provided with an ash hopper approximately 20 ft. long by 6 ft. deep by 5 ft. wide, divided into three compartments, each compartment having an opening at the bottom 30 in. wide and 60 in. long. Each of these openings is closed normally by a pan about 6 in. deep arranged to form, when closed, with the bottom of the hopper, a water seal to prevent the inflow of air behind the fire, and thus reduce the excess air from this source. Each pan is power-operated to deliver the ashes from the hopper to a railroad car placed directly below the setting of the boiler.

Combustion ash hoppers are provided beneath the superheater to catch the combustion ash and dust blown over from the fire. These hoppers can be cleaned out while the boiler is in operation, discharging the combustion dust into the same ash car as the main hoppers.

With the idea of making all possible use of the radiant energy of the fire in the furnace, which energy should vary almost directly with the total heat released in the furnace and consequently with the steam produced by the unit, it was decided to install the superheater in the opposite end of the setting from that occupied by the stoker, and to incline the loops of the elements downward toward the bridge-wall. With this arrangement, no hot gases pass through the superheater elements and all the superheat obtained is direct from

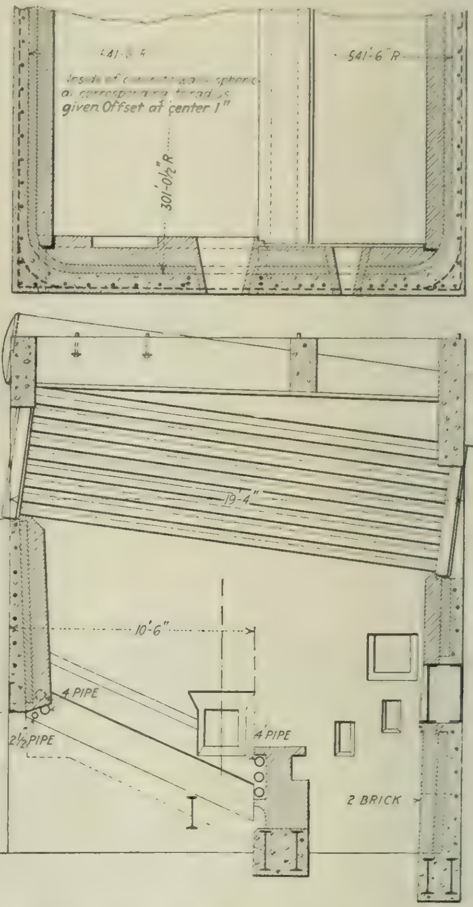


FIG. 5. SECTIONAL PLAN AND LONGITUDINAL ELEVATION, SHOWING SETTING WALL CONSTRUCTION

the radiant energy of the fire bed and the burning gases in the furnace. Due to the position of the headers the superheater is automatically self-flooding. This arrangement has worked out in a very satisfactory manner, giving nearly uniform superheat under all conditions of load and delivering properly superheated steam to the header both when going onto the line after a shutdown and when sudden demands for steam are made upon the unit. The superheating is done entirely by the radiant energy of the fire, which in most settings tends to melt the firebrick and raise the furnace temperatures to an abnormal point.

The setting for this unit, Figs. 4 and 5, consists of a monolithic outer coating of concrete about 9 in. thick, heavily reinforced. To this concrete shell are bolted all the access doors to the interior of the setting, and it is designed to carry the weight of the stack directly to the building members without throwing any stresses on the boiler or its supports. The concrete outer shell is lined with 4 in. of heat-insulating brick and 13 in. of firebrick. Each of the brick linings is laid up independent of the other and of the concrete shell, not even an occasional tie being used to bind them all together. The brickwork is laid against a spherical surface molded on the inner face of the concrete when it was poured. The chord circle of the sphere is inclined with the vertical so that the top of the inside of the concrete wall leans away from the boiler. This gives a concave arched surface standing almost vertically, against which the brickwork of the lining tends to lean heavily, and the concave side of a spherical dome toward the fire. The brick linings are free to expand both horizontally and vertically, expansion joints being provided in the corners of the setting and at the top of the walls.

After nearly a year of hard service this setting shows almost no cracks in the concrete, and the brick walls, with the exception of the front wall over the stoker retorts, are in as good condition as when first put in. Trouble has been experienced in holding the front wall over the stoker retorts. This has been due to a faulty dust seal, which allowed dust to work down between the brick wall and the concrete wall, wedging the former out and overthrowing it into the fire.

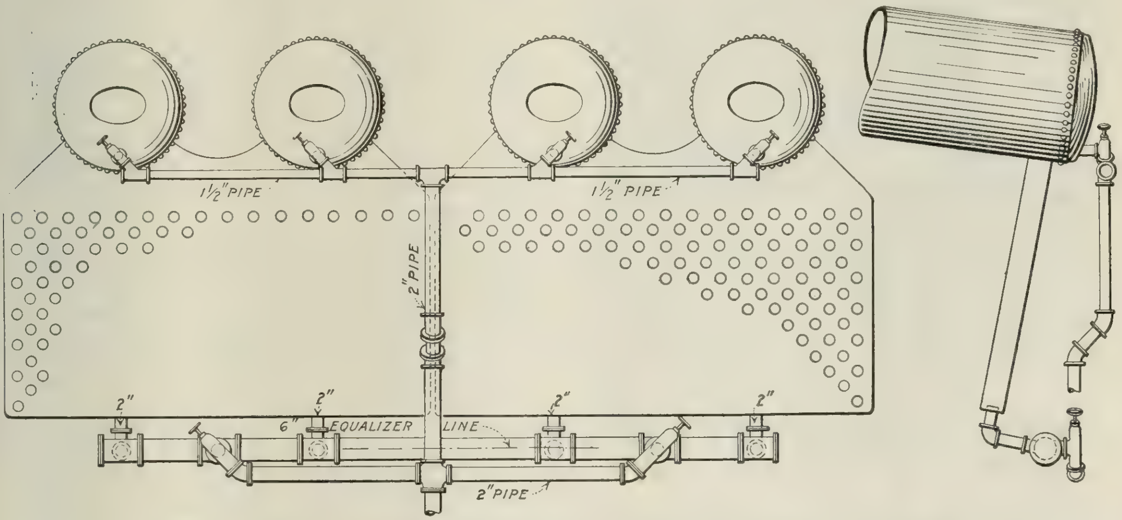


FIG. 6. THE SIX-INCH WATER-EQUALIZER CONNECTION BETWEEN THE BOILERS

In passing it may be noted that although this unit has been operated continuously except for cleaning periods at from 150 to 200 per cent. of rating, with occasional peaks as high as 300 per cent., the brickwork has not yet been hot enough to vitrify the high-temperature cement in which it was laid up. In fact, door liners cast from cement supposed to vitrify at 1600 deg. F. had to be discarded because there was not sufficient temperature to harden them and prevent their crumbling.

Two 406-hp. water-tube boilers, entirely independent of each other except for the steam, feed-water and equalizer connections between them, are hung from the steelwork of the building and from the unit now in operation. Being suspended independent of the setting, they are free to expand and contract without throwing any stresses into the brickwork or the concrete.

One of the points of interest in this installation is the 6-in. water-equalizer connection between the boilers, Fig. 6. This was intended to assist in keeping the water lines at the same height in the two boilers when both were fed from one feed valve. It has fully met this condition as it has maintained the water levels in the two boilers within two inches of each other when operating at 200 per cent. of rating, and with the feed shut off from both drums of one boiler.

Another point of interest is the inclination of the boiler tubes, which is 1½ in. per ft. instead of 1 in., the standard pitch of tube generally used with this type of boiler. The greater pitch was adopted because it was believed that under severe firing and sudden changes in steam demand a splitting or interruption of the circulation of the water in the lower rows of tubes might occur with the standard pitch. Two tubes recently removed from this boiler seem to confirm the soundness of this reasoning. They were bowed up away from the fire over seven inches in their length, thus indicating that the top of the tube had been at considerably higher temperature than the bottom, due doubtless to sluggish circulation caused by rapid formation of steam bubbles that accumulated at the top of the tube. It would appear that a tube pitch even greater than 1½ in. per ft. might be desirable to accelerate the circulation.

These boilers are horizontally baffled throughout with cast-iron baffle tile, which, contrary to prediction, does not warp, burn, crack or fall out. These tile were originally placed on the third row from the bottom, but have been removed recently to the fifth row to better equalize the gas velocities in the setting.

To facilitate the control of the operating conditions in the furnace, there are mounted on a control board, Fig. 7, convenient to the stoker-driving engine and in front of the boiler, a steam-flow meter, blast-pressure recorder, water-level recorder, steam-pressure recorder, illuminated-dial pressure gage, CO_2 recorder and a boiler-efficiency meter. These instruments provide the fireroom attendant with practically all the operating data required for the efficient operation of the unit. Hand-operated stack-damper control is provided for maintaining not over 0.05 in. water draft over the fire. As is frequently the case with hand-operated installations, this arrangement is not entirely successful, and automatic means for controlling the stack damper are under consideration.

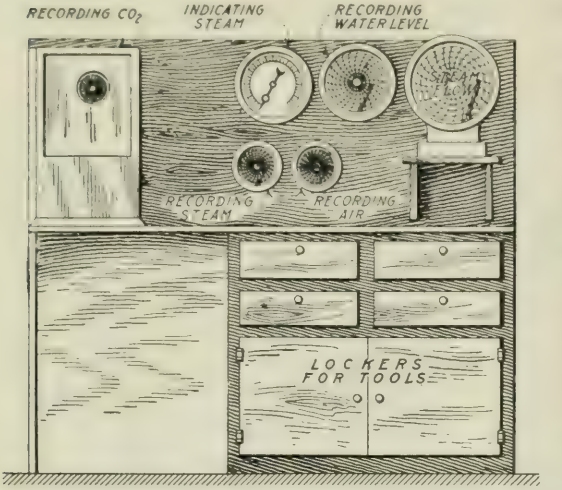


FIG. 7. CONTROL BOARD IN BOILER ROOM

The old boiler room was provided with a 2000-hp. open feed-water heater, a V-notch meter of 100,000 lb. per hour capacity, and a continuous water softener rated at 4000 gal. per hour, of the lime-and-soda type. This equipment treats, heats and meters the feed water, which is reduced to about two grains per gallon of hardness, and delivered to the boiler at a temperature of from 190 to 220 degrees.

Of the new unit the performance has been uniformly good. The superheat is quite constant, seldom varying 50 deg. from one day's end to another, and frequently running for days at a time with less than 10 deg. variation. Considering that there is no automatic means for regulating the superheat, but that the radiant energy of the fire and the amount of steam passing are the only controlling factors, this performance seems quite remarkable. The variation in the average superheat due to a change in load equal to 100 per cent. of the rating of the boiler causes little change in the superheat. In fact, this change in load could not be detected with certainty from the readings of the recording thermometer. Tests recently run on this unit at approximately 180 per cent. of the boiler rating showed a combined efficiency of 74.8 per cent. with coal of 9050 B.t.u. as fired, 14 per cent. moisture and 20 per cent. ash. The refuse produced in this test showed only 7 per cent. of combustible.

Recently, some very poor coal was received and burned at this plant. An analysis showed 16 per cent. moisture, 45 per cent. ash and a heat value of 4900 B.t.u. per lb. as fired. With this fuel the unit produced 950 boiler horsepower, 103 deg. superheat and showed a combined efficiency of about 80 per cent. These results were not obtained in a test, but were figured on the face of the flow-meter returns for 24 hours. This flow meter has been checked against weighed test results and has been found to be about 1 per cent. slow. A greater output could have been obtained with this fuel had it been possible to dispose of the ash as rapidly as it was formed, but the limitations imposed by the ash-handling end of the stoker, when called upon to handle nearly 300 per cent. more ash than it was designed for, limited the output to the figure given.

Economies figured on the basis of the flow-meter readings have run for 28 days at 70 per cent. or better combined efficiency. Sufficient tests have not been made, as yet, to determine at what output the maximum economy will be reached for this setting, but it seems likely that it lies near or beyond 200 per cent. of rating.

The labor required to operate this plant for 24 hours is three firemen and three helpers, or two men per shift. On one shift there are also one coal passer (crane man) and one car trimmer. This force is sufficient to handle all the coal required and the ashes produced by the unit. Indications are that no greater force will be necessary when the four units have been installed. The economies effected by the coal-handling apparatus alone on this unit approximate $1300 per month. When operating, the new unit displaces six 300-hp. boilers burning the same fuel in the old boiler room and has increased a two weeks' average evaporation by 0.9 lb. at the end of a second period of two weeks. The labor required for the old boiler room is nine firemen and six ashmen each 24 hours, from one to three coal passers and from six to 10 coal shovelers for 12 hours out of the 24.

The performance of the unit has justified the judgment on which the design was based. There remain, however, some details to be worked out before the mechanical operation will be entirely satisfactory. These details are of minor moment, wholly mechanical in nature, and present no unusual features.

From general reports France is poor in coal but not in water power. The best estimate places the hydroelectric resources of the country at five million primary horsepower and from four million to five million secondary, the first of these being available the year round and the second for six months of the year. Of this total only 750,000 horsepower had been developed in 1913. During the war, on the initiative of the government, 415,000 additional horsepower was developed, and other projects are now under way from which 125,000 hp. should be realized in 1919 and 225,000 hp. by 1921. This will carry the total water-power development to some 1,600,000 horsepower.

Production of gasoline from natural gas increased from 7 million gallons in 1911 to 104 million gallons in 1916.

Causes of Direct-Current Generators Failing To Build Up Their Voltage

By ROBIN BEACH
Associate Professor, Department of Electrical Engineering, Polytechnic Institute, Brooklyn, New York

Tells how a direct-current generator builds up its voltage, gives a number of causes why a machine may fail to come up to voltage and explains how to locate these faults.

THE two common types of direct-current generators now found in practical operation are shunt-excited machines and compound-excited machines. The latter may have the shunt field connected directly across the brushes—short shunt—as in Fig. 1, or connected across the armature and series field—long shunt—as in Fig. 2. When operating at no load, that is, with the generator switch open, a compound-wound generator is virtually a shunt-excited machine because the series fields do not function except under load conditions. Consequently, any discussion based on the no-load conditions of a shunt-wound generator will apply unconditionally to the compound-wound generator.

The establishment of potential difference at the terminals of a generator is affected by virtue of the revolving conductors on the armature cutting the magnetic field of the polepieces. This voltage varies as the number of lines of force cut per second. That is, for a given value of magnetism, doubling the rotational speed of the armature will exactly double the voltage generated, or for a given constant speed the voltage generated will be doubled if the magnetic-field strength is doubled.

A direct-current generator is self-exciting only by virtue of the fact that the iron polepieces retain a certain amount of magnetism when the field coils are not carrying current, so that as the armature rotates and reaches normal speed, a small voltage is generated and becomes available at the terminals of the machine. This small potential impressed across the field coils will cause a small current to flow through the field circuit. The magnetism which is produced due to the magnetomotive force of this current through the field turns adds to that of the residual magnetism and more voltage is produced, which in turn sends more current through the field coils. This process of "building-up" voltage would increase indefinitely, but for the fact that the field flux does not increase indefinitely, as shown in the curve, Fig. 3. It will be seen from this curve that at first the volts increase very rapidly, but gradually reach a point where there is practically no charge. This zone is known as the point of saturation; that is, the iron in the magnetic circuit is magnetized to a strength where the flux cannot be increased. It is somewhere near the point of saturation that the voltage of a generator reaches its maximum value. Values below this are obtained by connecting an adjustable-resistance—field rheostat—in series with the field winding, as in Figs. 1 and 2.

If a shunt- or compound-wound machine fails to build up, the effect may be traced to one or more of several causes. Following are a number of causes why direct-current generators may fail to come up to voltage: (1) Loss of residual magnetism; (2) magnetomotive force produced by the field coils opposed to the residual magnetism of the polepieces; (3) external resistance connected in the field circuit too high (such as a rheostat all cut in); (4) brush-contact resistance unduly high because of dirt and grease accumulation; (5) poor fit of the brushes on the commutator; (6) vibration of machine due to unstable foundation, worn bearings, high commutator bars or high mica; (7) external circuit closed through a low resistance; (8) too low rotational speed; (9) open in the shunt-field circuit; (10) brushes off the neutral position; (11) loose connections of brush pigtails or armature circuit to the machine terminals.

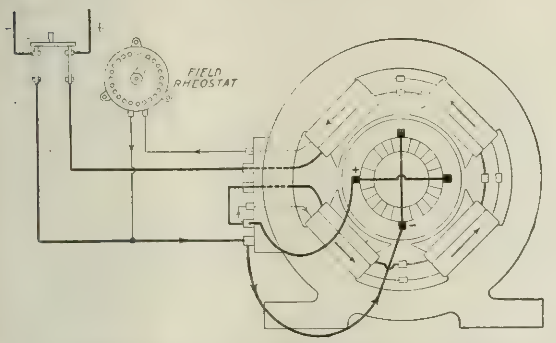


FIG. 1. COMPOUND-WOUND DIRECT-CURRENT GENERATOR CONNECTED SHORT-SHUNT

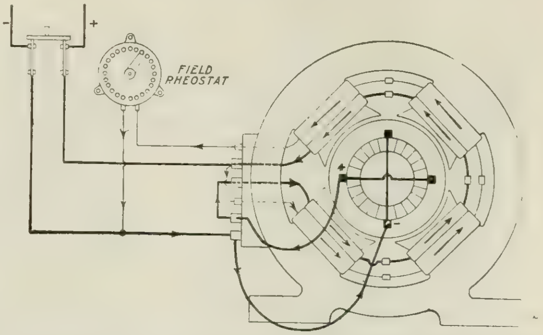


FIG. 2. COMPOUND-WOUND DIRECT-CURRENT GENERATOR CONNECTED LONG-SHUNT

1. The generator switch should in every case be open preliminary to the starting of the machine. When the generator is running at its normal rated speed, with the field circuit open, a voltmeter placed across the armature terminals should read a small voltage of the order of 5 to 15 or 20 volts, depending on the normal voltage of the machine. If a very low voltage or no voltage reading is obtained, the polepieces have lost their residual magnetism. The field coils must then be separately excited from another generator or from a battery source. If the machine is operating in parallel with another generator, the field can be excited the

proper polarity by opening the armature circuit and closing the switch, as on machine *A* in Fig. 4. In doing this care must be exercised to be sure that the armature circuit is open before closing the switch or the machine might be seriously damaged.

2. If the generator is operating at normal speed with the voltmeter across its terminals showing a residual voltage, but when the field circuit is closed this voltage is reduced, the current is then flowing through the field coils in the wrong direction so that their magnetomotive force bucks the residual magnetism. To remedy this condition the field terminals must be reversed.

3. The field-rheostat resistance should all be cut out of circuit when starting the generator so that the small residual voltage will send the largest possible current through the field windings.

4. Frequently, a machine will collect oil and dust particles to form a thin film under the brushes, so that when the residual voltage tends to send a current through the field coils the resistance at the brush contact surface is so high that the process of building up is rendered impossible. The commutator, brushes and brush-holders may be cleaned with gasoline.

5. Many times it is found that the brushes are making contact on only a limited portion of the surface, owing to a poor fit to the commutator, collection of dirt or to picking up copper particles from the commutator. In this case strips of sandpaper should be prepared a little wider than the brushes and a good fit procured by sandpapering each brush only in the direction of rotation, lifting it on the return.

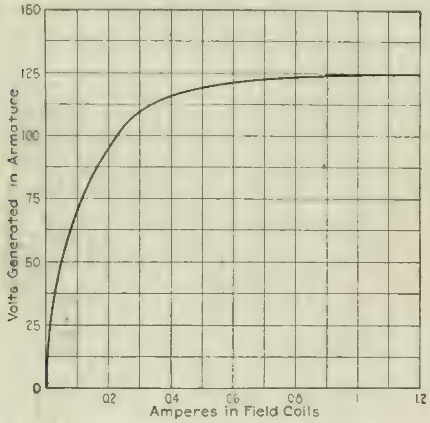


FIG. 3. VOLTAGE OR SATURATION CURVE OF A DIRECT-CURRENT GENERATOR

6. Not infrequently is it found that the brush-contact resistance is made critically high because of vibration of the armature from one or more of various reasons. This mechanical difficulty may be observed and corrected if it is caused by the foundation or badly worn bearings. Sometimes the brushes are made to vibrate because of high commutator bars or mica-insulation projection. When this is the case the commutator must be turned down on a lathe or ground by using a stone. Pressing on the brushes will usually affect the voltage in case of vibration difficulties.

7. If the external circuit is left closed through a low resistance, the residual voltage at the terminals of the machine will not be maintained, because of the internal voltage drop in the armature, and the machine will not build up. The machine must always be disconnected from its load before starting.

8. When the speed is low, the voltage generated is proportionately low, which is substantially equivalent to an increased resistance in the shunt-field circuit. That is, a machine may build up with a given rheostat setting at a high speed; but when the speed is reduced it may not build up until the resistance is decreased below the critical value for this speed. The remedy is to get the machine up to normal speed.

9. An open-circuit in the shunt-field circuit may be located by connecting the field coils to a source of power and taking voltage reading across the coil terminals until the open-circuit is found, as in Fig. 5. The voltmeter will read practically full voltage when connected across the terminals of the defective coil. A lamp may be used for the same purpose, and will light up when connected across the defective coil's terminals; its brilliancy will depend upon the resistance of the coils.

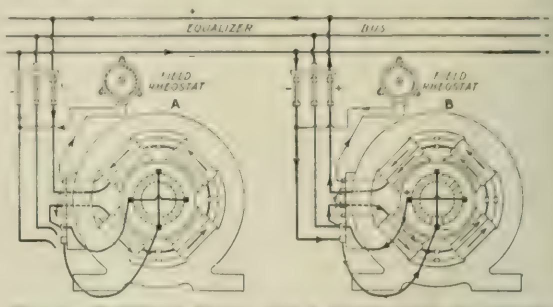


FIG. 4. EXCITING FIELD COILS WHEN TWO MACHINES ARE CONNECTED IN PARALLEL

10. When the brushes are moved off the neutral position, the voltage available at the machine terminals is less than when the brushes are located on the neutral. The farther off the neutral they are the less the voltage will be until at 90 electrical degrees the voltage is zero. The brushes should be set on the commutator where the maximum voltage occurs.

11. Sometimes when the foregoing remedies do not clear the trouble, it may be traced to poor connections in the brush circuits due to brush pigtails loosening or to faulty connection to rocker-arm studs.

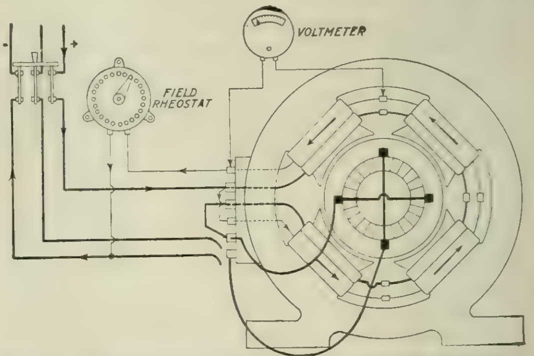


FIG. 5. METHOD OF TESTING FOR DEFECTIVE FIELD COILS WITH A VOLTMETER

An attempt to separately excite the machine at the early stage of the investigation will very often eliminate many of the foregoing factors at once and make the solution quite simple.

Very recently, the author was called upon to investigate the failure of a machine to build up. It was a

1400 r.p.m. Speeds above 700 r.p.m. are obtained by 600-ampere 6-volt machine for electrolytic purposes. The difficulties found were: First, the machine vibrated badly because of poor foundation; second, the brushes were considerably off neutral; third, the brush fit was very poor. After remedying these defects, the machine came up to voltage; however, as soon as a load of 15 amperes was put on it, the voltage immediately fell to zero. The series fields were reversed, but the same thing happened. The brushes were moved to observe the effect on the voltage, but this did not improve matters. It was finally concluded that a very large drop occurred at the brush-contact surface. This was taken up with the company from whom the machine was purchased, and it was found that through an error carbon brushes had been sent out with it. The substitution of metal-graphite brushes immediately solved the whole problem. For carbon brushes a drop of two volts is a fair average per set of brushes while for metal-graphite it is only about 0.2 volt. Brush-contact drop is a point of vital concern on a low-voltage machine.

Reliance Automatic Coal Scale

A coal scale for power-plant use has been developed recently by the James A. Brady Foundry Co., of Chicago. It is known as the Reliance automatic coal scale and for continuous weighing is claimed to be accurate within one per cent. Coal comes to the scale from the overhead bunker through a pipe that is attached to a casting forming a part of the scale frame. This casting stands about five inches above a horizontal circular rotating disk which supports the coal in the form of a conical pile (see Fig. 1). Above the disk there is a stationary casting which serves to scrape off a certain amount of coal as the disk is revolved on its axis by a motor or through a belt connection to a lineshaft. From the disk the coal falls into a cast-iron weigh hopper having vertical sides and rounded corners, as shown.

As the unit weighment is approximated, the balanced scale beam begins to tip down. The first part of this motion throws out the clutch driving the speed disk and stops the discharge of coal into the hopper. A sliding weight serves to compensate for the amount of coal momentarily in suspension and makes the net weight of coal actually delivered to the hopper the exact amount desired. The second part of the downward travel of the weigh hopper trips the balanced gate serving as a hopper bottom, and the coal is all dumped out. When the last piece of coal clears the hopper bottom, the weigh hopper starts to return to its original position. The slightly overbalanced bottom first closes, and then the driving clutch is thrown in and the coal feed is resumed. It is possible to adjust the compensating weight at the second trial weighment, and when this is once adjusted the scale will continue to operate accurately as long as coal is delivered to it.

Should the chute or hopper below the scale become filled, the weigh hopper will not completely discharge and the hopper bottom will remain open as long as there is any coal resting on it. As the fireman removes the coal from the bottom of the chute, the coal will gradually work out of the hopper and when the last particle is out, the bottom will close as previously described. It takes about ten seconds for a dump to be made, so that it is readily possible to make 100 weighments an hour, including the filling of the hopper. In ordinary operation the number of weighments will depend upon the rate of feed to the stokers, and this is automatically controlled as previously described.

The scale is all cast-iron construction and has a straight-sided hopper. Hardened-steel knife-edges are housed in a cast-iron box with a felt washer so placed as to exclude the dust from the coal. From the illustrations it will be apparent that the apparatus has a heavy frame of box section to prevent distortion of the weighing element should the scale happen to be unevenly supported. To reduce the amount of counterweight necessary and lighten the stress on the wearing parts, the ratio of the two arms of the balanced lever is four to one. The operating shaft is inclosed in a dustproof case and it is carried in ball bearings. Upon request a set of flanged wheels are attached to the scale frame, making it possible to roll the scale out from under the coal chute should it be desired to use it in more than one locality. An automatic counter is furnished with each scale, and this may be attached directly to the frame, as shown in Fig. 3, or it may be located on the boiler-room wall where it can be seen easily and read by the boiler attendant.

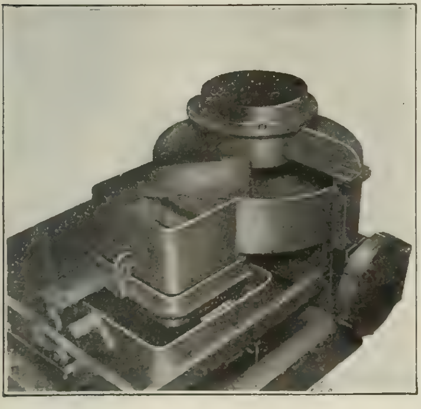


FIG. 1. SCALE SHOWING ROTATING DISK, SCRAPER AND TOP OF WEIGH HOPPER

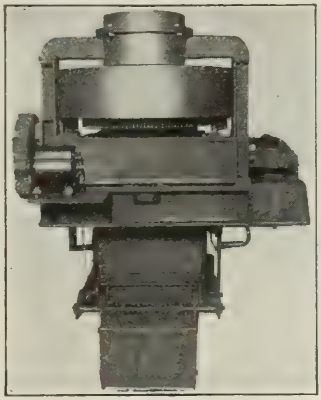


FIG. 2. FRONT VIEW OF SCALE SHOWING DRIVING GEARS AND MOTOR

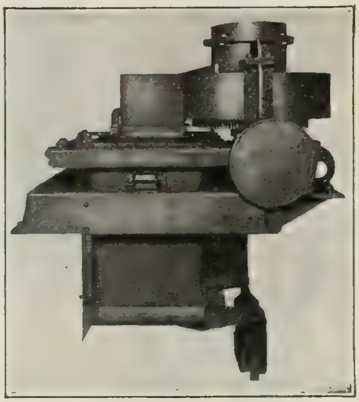
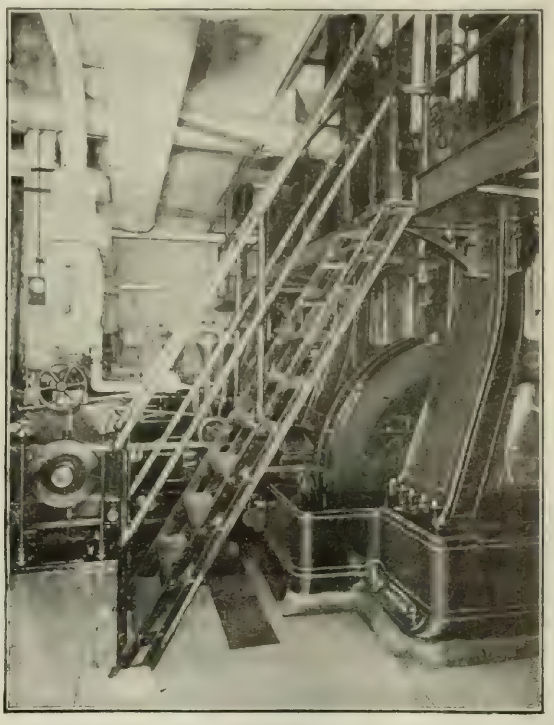


FIG. 3. SIDE VIEW OF SCALE SHOWING HOPPER BOTTOM AND COUNTER

Furnish the finish—the Victory Liberty Loan.

Refrigerating Equipment of the Pennsylvania Hotel



A FEW years ago the story of making artificial ice sounded to the layman very much like a tale by Jules Verne or some other equally great romancer in natural laws. Yet today artificial ice and refrigeration have become such important factors in our existence as to rank with sanitation, pure-water supply, etc., and are accepted in the same commonplace way as all other necessities for human existence. Probably one of the best examples of the importance of artificial refrigeration is found in a modern hostelry such as the Hotel Pennsylvania, New York City. One has only to consider that if the total capacity of the refrigeration plant in this hotel was utilized for ice making, 100 tons of ice could be produced every 24 hours, sufficient to supply a city of 50,000 population with ice for family use. As pointed out in the article, "Mechanical Equipment of a Modern Hotel," in the Feb. 18, issue, the decision on how the power-plant equipment should be driven was made only after a very careful study of the hotel's exhaust-steam requirements, by the consulting engineers, Messrs. Tenny and Ohmes, on heating, ventilating and refrigerating equipment, and by Charles E. Knox on the electrical equipment, for the architects, McKim, Mead & White. As a result of these investigations it was found that the refrigeration machinery could be most economically driven by steam engines, since all the exhaust steam can be used through the year for heating and cooking purposes.

The refrigeration machines are three in number, each having a capacity of 65 tons of refrigeration at normal speed. Each unit consists of two vertical single-acting ammonia compressors directly connected to each end of the crankshaft of a horizontal Corliss engine (see headpiece) operating on a steam pressure of 150 lb. per sq.in. The condenser is of the double-pipe countercurrent type, having a capacity of 200 tons. Two receivers are used, each 20 in. diameter by 15 ft. long, built of steel, with welded heads tested to a hydrostatic pressure of 500 lb. per square inch. There are three brine coolers—one for the low-pressure brine system, one for the high-pressure brine system and one for the ice-cream freezers—having a total of 14 sections. The coolers are of the double-pipe countercurrent type, each section being 10 pipes high by 20 ft. long, made up of 1½ in. x 2½-in. pipe. For circulating the brine there are six pumps, three steam-driven end-packed plunger type and three motor-driven centrifugal pumps. The high-pressure centrifugal pump is provided with a cast-steel casing that will withstand a static-head pressure of 500 ft. All the centrifugal pumps run at a maximum of

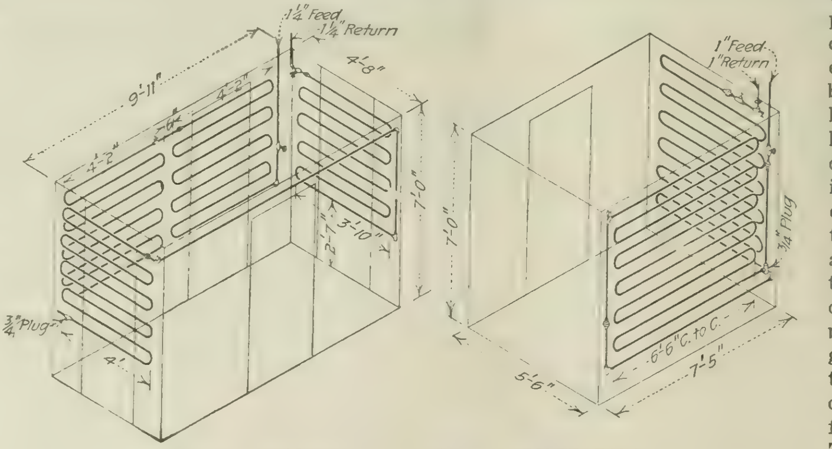


FIG. 1. DIAGRAMS OF TYPICAL REFRIGERATORS

1400 r.p.m. Speeds above 700 r.p.m. are obtained by shunt-field control of the motors.

The plunger pumps are full brass fitted, with brass-lined water cylinders, seat valves and water pistons and bronze piston rods. The centrifugal pumps have bronze impellers mounted on bronze-covered steel shafts.

There are approximately 100 refrigerating boxes throughout the building, totaling 35,000 cu.ft. contents. They contain coils, made up of 1¼-in. extra-strong galvanized pipe, sufficient to maintain the specified temperature in the boxes. Typical refrigerators are shown in Fig. 1. The ice-cream boxes are designed to maintain a temperature of 10 deg. F.; others are for temperatures suitable for the material they are to contain. The pastry cooks' refrigerator, for example, does not require a temperature lower than 50 or 40 deg. F. Brine is the cooling medium for these boxes (no ammonia is used above the basement), and it is circulated in three systems of piping: The high-pressure, for all parts of the building above the first floor; the low-pressure, for the first floor and below, including the 20 x 34-ft. ice-skating rink in the basement grillroom; and the ice-cream system, for all boxes requiring 20 deg. F. or lower temparature. Each system has duplicate circulating pumps; one is steam- and the other electrically driven.

The ice-making equipment is comparatively small, as the demand for ice is limited to a few special uses in dining rooms, etc. The freezing tank is approximately 55 ft. long, 12 ft. wide and 4 ft. deep and will take 200 cans of 300 lb. each. It is fitted with 800 lin.ft. of 1¼-in. direct-expansion ammonia coils. An electric traveling crane over the freezing tanks handles two cans of ice at once, conveying them to the "hot well" for thawing the ice free from the cans. The water in the hot well is kept hot by submerged steam pipes, and two cans of ice may be lowered into it at once, but none of the hot water comes into contact with the ice. The cans are then carried by the crane to the "can dump," from which the ice is delivered by gravity to the storage room.

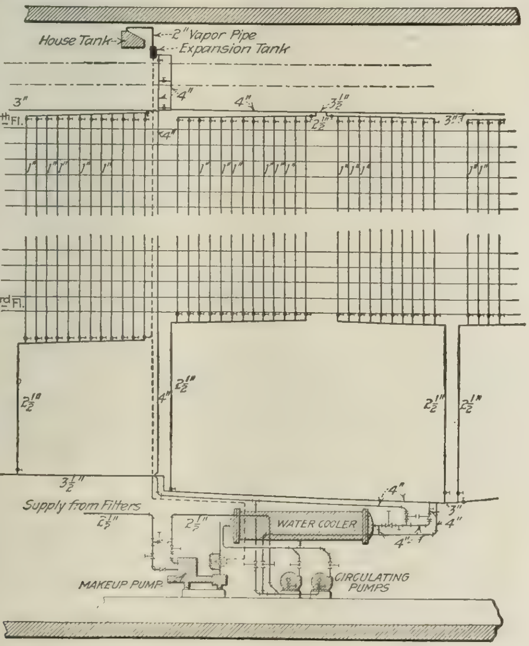


FIG. 2. DRINKING-WATER COOLING SYSTEM

Air agitation for the water in the ice cans is supplied by a motor-driven compressor. The air is taken from the fresh-air duct of the engine room and piped through the ice-storage room, where it is chilled before entering the compressor so that it is delivered to the ice cans nearly moisture free and in a condition to secure the maximum amount of clear ice. The water for ice making is first passed through a primary and a secondary set of filters of 24 units each, thence to the ice-making water-supply tank, where it is precooled to 40 deg. by a direct-expansion ammonia coil before being delivered to the freezing cans. A motor-driven centrifugal pump is used to agitate the brine in the freezing tank.

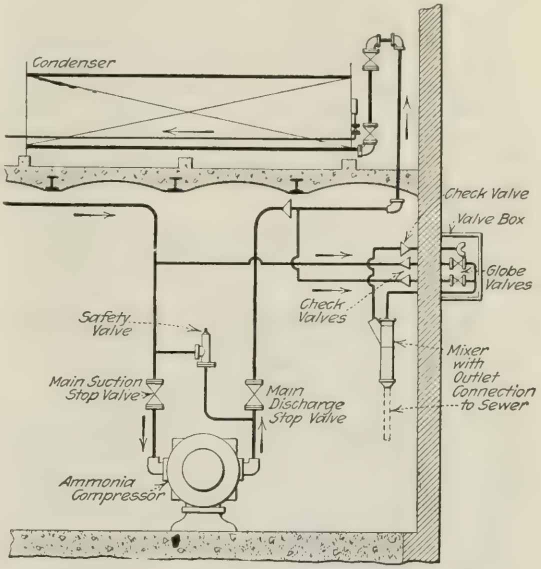


FIG. 3. ARRANGEMENT OF SAFETY CONNECTIONS

An ice-cutting room is located near the storage room, in which there are two "cubers" and two crushers. One of the cubers has a cutting capacity of 6000 1½-in. and the other 5000 2-in. cubes per hour. The crushers have an hourly capacity of five tons each.

The drinking water is first passed through filters, then cooled to 40 deg. F. in a circular galvanized-iron tank containing 1580 lin.ft. of 2-in. direct-expansion ammonia pipe coils. These coils are helical and four in number, each independent of the other, with outside connections to the ammonia system, so that any or all may be put into service as desired. Fig. 2 shows the pressure drinking-water cooling tank in the basement, with pipe sizes indicated, a typical set of risers, and the expansion tank at the top of the building. It will be seen by tracing the piping to and from the circulating pumps that the water may be fed through the cooling tank into the risers and returned through a common return pipe from the expansion tank, or it may be discharged through the cooling tank to the expansion tank, thence downward through the service pipes as may be desired. The service pipes supply approximately 2300 taps with water at about 40 deg. F. This piping is arranged in groups above the third floor as shown and valved top and bottom so that any riser may be shut off independently, or the whole section may be shut off at the main valves.

A safety valve is connected between the ammonia discharge or compression piping, near each compressor, and the low-pressure or suction piping, to relieve the system of overpressure. Also there is an arrangement of piping for discharging all the ammonia under pressure into a mixer, where sufficient water may be added to absorb all the gas and carry it off to the sewer. This piping is extended to an emergency valve located outside of the building at the sidewalk, as shown in Fig. 3, and provided with a standard fire department siamese so that the ammonia system may be emptied into the sewer from this point by a fireman or police officer in case of emergency, as is required by the New York City regulations.

(An article describing the electrical and elevator equipment in this hotel will appear in an early issue.)

Electrical Recording of Boiler-Heat Losses

By John B. C. Kershaw

An interesting type of instrument for measuring and recording the heat losses in chimney gases, depending upon a new principle, has been devised by a French chemist, M. Chopin, and was described before a recent meeting of the *"Academie des Sciences."*

The working of the instrument is based on the measurement of two electric currents, the intensity of the one being dependent upon and varying with the temperature of the waste gases, and the intensity of the other being dependent upon and varying with the percentage of CO_2 contained in the same gases.

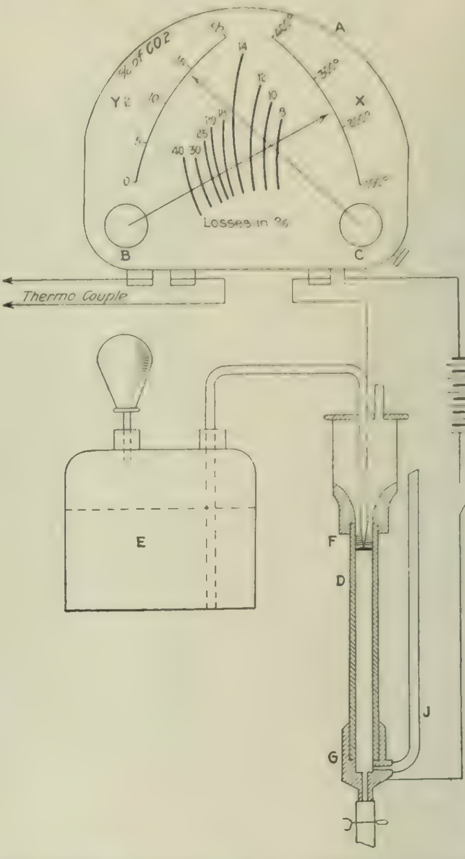
The first measurement is obtained by means of an ordinary thermocouple placed in the path of the gases, and the second is obtained by measuring the electrical resistance of a solution of caustic soda of known strength and volume, through which a definite volume of the chimney gases is passed. The absorption of CO_2 by the caustic soda and the formation of sodium carbonate cause an increase in the electrical resistance and therefore a diminution in the current that can be passed through the solution with a constant electromotive force, for the conductivity of sodium carbonate in solution is only one-third that of caustic-soda solutions.

The most striking and original feature of the instrument, however, is that by which the results of the two measurements are automatically converted into percentage heat losses, which can thus be read off by the engineer or fireman in charge of the boilers, without any necessity for complicated or involved calculations.

The arrangement of the apparatus and mechanism is shown diagrammatically in the illustration, where *A* is the indicating dial, *B* is the indicating finger that records the temperature of the gases on the scale marked *X*, by means of the thermocouple shown below it, and *C* is the indicating finger that records the percentage by volume of CO_2 in the waste gases, on the scale marked *Y* by means of the electrical-resistance measurement of the solution contained in the vessel *D*.

The point where these two indicating fingers cross each other on the recording dial gives the percentage of heat losses, since the curved lines represent the results of calculations for the other fixed factors that enter into the equation.

As regards the other parts of the apparatus, *E* is the vessel in which the caustic-soda solution is prepared and stored before use; *J* is the pipe by means of which the waste gases are conducted into the mixing tube or burette *D*, which serves not only to measure the volume of chimney gas, but also to give a definite volume and length of electrolyte between the nickel electrodes at *F* and *G*. After each test the solution of caustic soda, containing more or less carbonate, is run off from the bottom of the absorbing and measuring burette. A fresh volume of gas is then admitted, and this is treated with the caustic-soda solution, pumped over from the vessel *E* by aid of a hand pump.



INSTRUMENT FOR RECORDING LOSSES IN CHIMNEY GASES

It is reported that the Missouri Senate Committee on Judiciary recently submitted a favorable report on a bill introduced by Senator Gardner, of St. Louis County, giving the State Public Service Commission the power to regulate rates for electricity generated outside of the state and sold in Missouri. The object of the bill is to regulate the rates of the Keokuk Plant, on the Mississippi River, from which St. Louis and other cities in the eastern part of the state obtain a large amount of electric energy.

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Combustion of Lignites and High-Moisture Fuels

By T. A. MARSH
Chief Engineer, Green Engineering Company, East Chicago, Ind.

Types of stoker adaptable to the burning of lignites containing as high as 35 per cent. moisture, at efficiencies approximating 70 per cent. Pre-drying is considered impractical. The drying must be done in the furnace in which the lignite is burned.

AMONG the lowest grades of fuel with which combustion engineers must work are the lignites and high-moisture coals. Many of these fuels contain more than 40 per cent. of moisture and less than 6000 B.t.u. per pound when mined. From such fuel it is evident that even after obtaining satisfactory combustion, the net heat delivered to the boiler is small, due to the low initial heat value and the loss due to evaporation of the moisture in the coal. The problem has presented such difficulties that there is a prevalent opinion that lignites cannot be burned successfully. It is the purpose of this article to describe methods of burning these fuels and to give results obtained in their combustion.

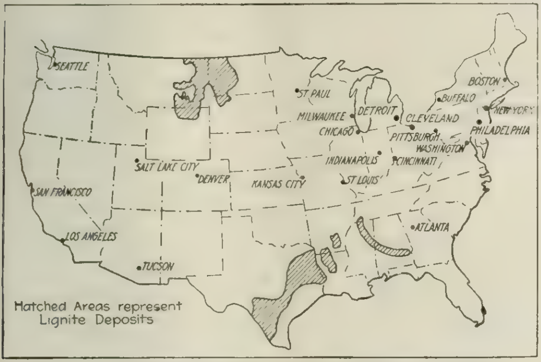


FIG. 1. LIGNITE AREAS OF THE UNITED STATES

The lignite deposits of North America occur in five main areas: North Territory and Alaska, Alberta and Saskatchewan, North Dakota and Montana (Fort Union region), Texas region, Mississippi and Southern Alabama (Mississippi River). The lignite areas of the United States are indicated on the map, Fig. 1. There are areas in Wyoming and Colorado containing high-moisture coals, 20 to 30 per cent., that will be discussed also in this article.

Lignites contain on the average from 20 to 40 per cent. of moisture when mined. These fuels have a spongy structure and woody fiber. They slack on the surface within a few hours when exposed, the action being similar to that of lime. Unfortunately, the drying process does not penetrate deeply into the pile, but is a surface action. On account of the high percentage of moisture and the slacking property of lignite, it cannot be transported successfully far from the mine, so that the development of this fuel has been limited.

Combustion of high-moisture fuels divides itself into two distinct processes—the drying of the fuel and the burning of the dry fuel. There are two methods of approaching the problem—by pre-drying the fuel before it enters the furnace or drying it in the furnace.

Pre-drying lignite at the rates desired in most plants is prohibitive both on account of the apparatus involved and on account of the cost of coal for the process. Unless, therefore, some waste-heat method of pre-drying is developed, there is little to be hoped for along this line.

All furnaces that successfully burn lignite have in them elements designed to dry the fuel, preparing it for the later stages of combustion. Evaporation can occur only from the surface, as the fuel burns, leaving exposed more moist fuel below to dry and burn. Complete combustion of all the lignite necessitates thin fuel beds. Everyone having experience with lignites is familiar with this fact. With hand firing it is difficult to keep the fire thin enough and at the same time free from holes.

Two types of stoker are producing excellent results—the plain chain grate and the "L" type chain grate with inclined coking plates. On a chain grate the volatile gases burn off rapidly after the fuel is dry, leaving a bed of fuel burning with little flame, similar to charcoal. This burns out to a fine, light, white ash.

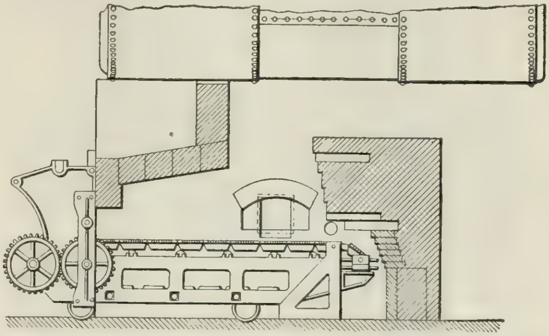


FIG. 2. A FURNACE SUCCESSFULLY BURNING LIGNITE

The "L" type chain grate with inclined coking plates at the front has produced excellent results with lignites. The coking plates tip up the front part of the fuel bed at an angle to the hotter portion of the fire, and ignition is thereby intensified. The incline serves as a drying region and the stirring action obtained by the fuel cascading over the coking plates serves to expose practically all surfaces of the fuel to the drying action of the furnace temperatures. The fuel, therefore, reaches the grate ignited and ready for rapid combustion.

With these fuels extremely high draft is not essential for high combustion rates, as it is possible to burn liberal amounts of "coal as fired" per square foot of grate with moderate draft. Table I gives rough estimates of the relation of draft in the furnace to the combustion rates of coal as fired.

In all calculations of draft involving areas of boiler passes, flues and chimneys, allowance must be made for the high rate of coal per horsepower with these fuels. For instance, 6.6 lb. of Malakoff lignite containing 7124 B.t.u. and burned at 71.3 per cent. efficiency is required per horsepower developed. All calculations should therefore be made on pounds of coal and not on any predetermined table or rules based on horsepower developed.

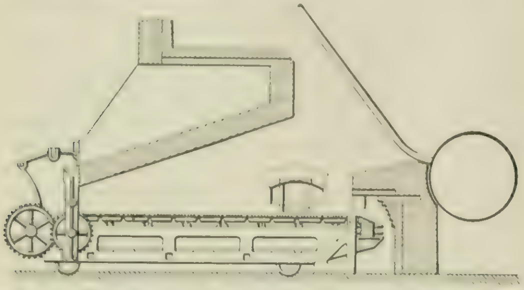


FIG. 3. FURNACE FOR BURNING LIGNITE UNDER THE STIRLING TYPE BOILER

It is only within the last five years that furnaces have been developed to successfully burn these fuels. So little has been said regarding this development that the results obtained are not common knowledge. A typical analysis of North Dakota lignite is given in Table II. On account of the high moisture content, no successful commercial method has been found for burning this fuel. There are, therefore, large areas of this lignite waiting on the further development of the art of combustion. That part of this field which extends beyond the Canadian border, however, bears lignites sufficiently low in moisture to permit of successful combustion. It is called "Souris lignite" and a typical analysis is given in Table III.

TABLE I. FURNACE DRAFT FOR VARIOUS RATES OF COMBUSTION

Coal as Fired per Sq. Ft. of Grate Area, per Hr., Lb.	Furnace Draft In. of Water
10	0.06
20	0.15
30	0.25
40	0.37

This fuel is being burned on chain grates in many plants with success. Large grate areas are, of course, necessary; usually at least one square foot of grate for each 30 sq.ft. of steam-making surface. A type of furnace successfully burning this fuel is shown in Fig. 2. The elements required in this furnace are a liberal igniting arch and a vertical bridge-wall or preferably an arch at the rear, reflecting the heat forward and deflecting the gases forward over the fuel. Such a furnace will ignite and burn 30 lb. of the lignite in Table III per square foot of grate area per hour.

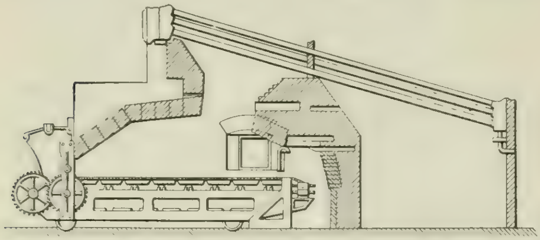


FIG. 4. FURNACE FOR BURNING THE SOUTHWESTERN LIGNITES

The lignites of Colorado do not contain as high a percentage of moisture, 30 per cent. being about the maximum. Pike View lignite of the analysis given in Table IV is typical. Danville lignite contains a higher percentage of ash and slightly lower moisture than Pike View. Both are found in the Colorado Springs district.

Several years ago furnaces were developed that would burn these fuels at good combustion rates. The figures in Table V give results obtained eight years ago on chain grates from Pike View lignite. Results from modern furnaces would appreciably surpass these figures.

TABLE II. TYPICAL ANALYSIS OF NORTH DAKOTA LIGNITE

Moisture, per cent	41
Volatile, per cent	24
Fixed carbon, per cent	27
Ash, per cent	8
B.t.u., commercial	6,241
B.t.u., dry basis	11,932

A number of plants are using this fuel. A typical installation in connection with a Stirling boiler is shown in Fig. 3. This setting is giving high combustion rates and high efficiencies from these high-moisture fuels.

In Texas the vast lignite fields are practically undeveloped. In this section of the country lignite must compete with coals of Texas, as well as those of Arkansas, Oklahoma and New Mexico. In addition oil and natural gas offer cheap fuels, so that the development of furnaces for burning lignite naturally has been retarded. Many of these lignites have been burned with excellent results on chain grates. A design of furnace developed for these fuels is shown in Fig. 4. In addition to the ignition arch there is a reversed arch from the bridge-wall, bringing the heat forward over the fuel bed. This construction is to be recommended for the combustion of lignites. An analysis of the fuel burned and some typical results with this furnace are given in Table VI.

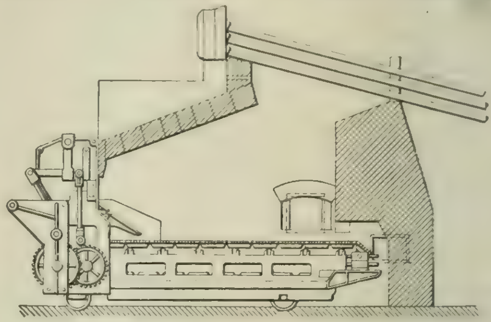


FIG. 5. THE STOKER HAS INCLINED COKING PLATES

TABLE III. TYPICAL ANALYSIS OF SOURIS LIGNITE

Moisture, per cent	29.7
Volatile, per cent	30.3
Fixed carbon, per cent	31.0
Ash, per cent	9.0
B.t.u., commercial basis	7,571
B.t.u., dry basis	10,770

TABLE IV. ANALYSIS OF PIKE VIEW LIGNITE

Moisture, per cent	23.73
Volatile, per cent	35.25
Fixed carbon, per cent	33.23
Ash, per cent	7.79
B.t.u., commercial basis	8,511
B.t.u., dry basis	11,160

Some interesting results have been obtained with the coking type "L" chain grate, shown in Fig. 5.

In addition to the usual horizontal chain-grate surface, it has an inclined coking plate approximately 3 ft. long. When burning lignites, this inclined surface serves as an excellent drying zone. Tipped up as it is, at an angle to the hotter portion of the fire at the rear, the drying progresses rapidly, so that by the time the fuel has reached the horizontal chain surface, the moisture has been driven off and the fuel has become thoroughly ignited. Results from this furnace burning Calvert (Tex.) lignite, are given in Table VII.

TABLE V. RESULTS OBTAINED EIGHT YEARS AGO FROM PIKE VIEW LIGNITE

Type of stoker	Green chain grate
Type of boiler	B. & W.
Coal per sq.ft. per hr., lb	28
Furnace draft, in. of water	0.23
COe at damper, per cent	12
Per cent. of rating developed	128
Combined efficiency, per cent	69.7

Considering the high percentages of moisture (24 to 30 per cent. in the fuels previously discussed) efficiencies of 67 to 72 per cent. are creditable, it being impossible to develop the high efficiencies obtained from low-moisture fuels. Such fuels as Calvert lignite with 30 per cent. moisture require 372 B.t.u. per pound simply to evaporate the moisture that is in the fuel and heat the resultant steam to a temperature of 500 deg. F., assuming a temperature of 80 deg. F. in the boiler room. The heat thus used is 5 per cent. of the total heat in the fuel as fired, and must detract directly from the efficiency of steam generation.

TABLE VI. RESULTS FROM SPECIAL FURNACE DESIGNED FOR BURNING LIGNITES

	Malakoff	Treadlew
Moisture, per cent	29.93	29.80
Volatile, per cent	30 96	31.34
Fixed carbon, per cent	25 46	23.71
Ash, per cent	11 66	13 15
B.t.u., commercial	7,124	6,906
B.t.u., dry basis	10,314	9,838
Type of stoker	Green chain grate	Green chain grate
Type of boiler	B. & W.	B. & W.
CO_2 at damper	11.81	12.2
Coal per sq.ft. per hr., lb	30.6	31.6
Draft in furnace, in	0.32	0.24
Combined efficiency, per cent	71.3	69

TABLE VII. RESULTS FROM "L" TYPE CHAIN GRATE BURNING CALVERT LIGNITE

Name of fuel	Calvert (Tex.) Lignite
Moisture, per cent	30.17
Volatile, per cent	38.33
Fixed carbon, per cent	24.03
Ash, per cent	7.48
B.t.u., commercial basis	7,462
B.t.u. dry basis	10,669
Kind of boiler	Babcock & Wilcox
Kind of stoker	Green "L" type chain grate
Coal per sq.ft. of grate per hr., lb	36.4
Furnace draft, in	0.34
CO_2 at damper	11.2
Combined efficiency, per cent	67

With established results averaging about 70 per cent., and with many plants successfully burning lignites containing as high as 35 per cent. moisture and only 6800 B.t.u., plant owners, engineers and designers in localities where these fuels are involved can, with assurance, base calculations and designs on the use of lignites.

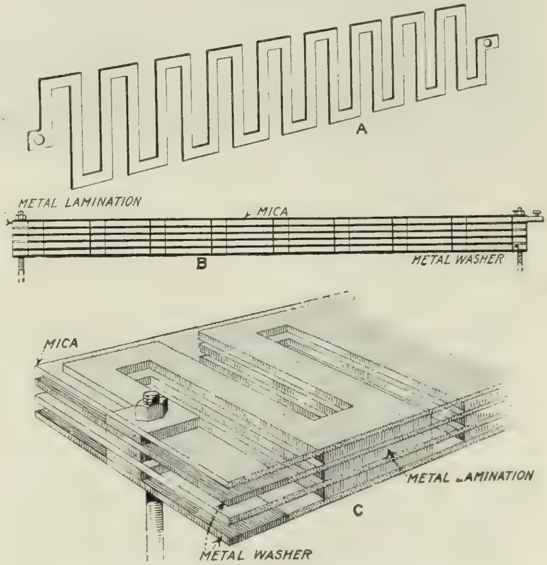
It is anticipated that construction work will begin in the course of a few weeks on the dam of the Georgia-Alabama Power Co. on the Flint River, about two miles above Albany, Ga. A concrete dam will be placed in the river at Porter Shoals and work will be under way by early summer. With the damming of the river, something like 12,000 additional horsepower will be made available to meet the increasing demand for electric energy.

Trouble Caused by Faulty Construction

By E. C. Parham

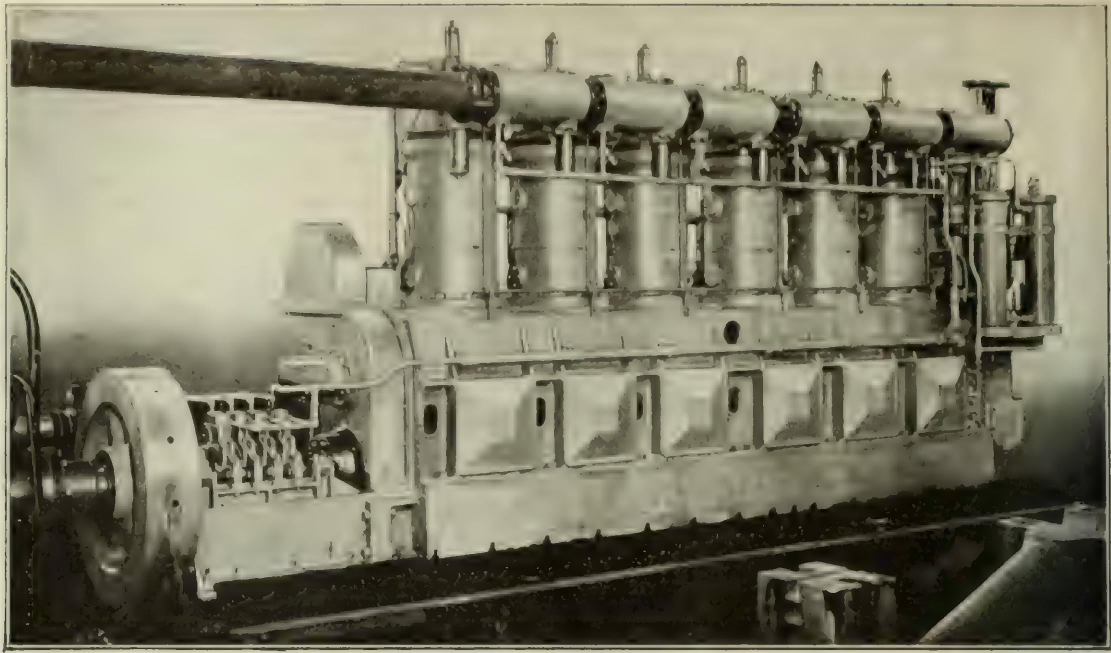
Diagram *A* in the figure shows one of the iron laminations used as the unit resistance element of a certain type of starting rheostat. Due to the slots punched in the sides, a current entering at one end must take a zigzag path to the other end, thereby traversing a considerable length of metal. In the building of a complete rheostat these elements are assembled alternately with thin unslotted strips of mica so placed as to insulate the punchings from each other excepting at alternate ends as shown at *B*. It is evident that with this construction a current entering at one end of a completed rheostat must traverse the full length of all laminations in order to reach the other end of the rheostat. An enlarged view of the assembly is given at *C*.

A number of motors were giving trouble by blowing the fuses when started. When the motors were first installed they started satisfactorily, but after being in service for a short time they began to act as if the starter did not have sufficient resistance, and frequently the fuses would blow owing to the inrush of current when the starter was placed on the first point. It was finally decided to take one of the resistances apart.



CONSTRUCTION DETAILS OF GRID RHEOSTAT

Factory-made resistance laminations are generally rolled after being punched in order to remove the burrs due to the punching operation. The laminations in the starters in question had the appearance of having been sawed and they certainly had never been rolled, because the slots had burrs the length of which very much exceeded the thickness of the mica separators. The result was that even the normal pressure incident to firm asembly was sufficient to force some of the projecting burrs through the intervening mica, and this condition became aggravated when heat due to usage caused the laminations to expand and buckle. After dismantling each resistance and cleaning the burrs from the laminations and assembling again, no more trouble was experienced.



McIntosh & Seymour Marine Diesel Engine

Some of the details of a four-stroke-cycle Diesel engine for marine service. It is directly reversible and uses no reversing gear between the engine shaft and the propeller shaft.

INCREASED production of marine Diesel engines both at home and abroad has been one of the interesting developments of the war. A typical modern engine of this class is that built by the McIntosh & Seymour Corporation, views of the opposite sides of which are shown in the headpiece and Fig. 1. It is of six-cylinder construction and develops 500 hp. at 185 r.p.m. Each cylinder has a bore of 16 in. and a stroke of 24 in. and the engine works on the four-stroke cycle.

The cast-iron bedplate is of the box type and is strongly reinforced with vertical ribs. The bottom forms an oil pan that slopes toward the rear end and receives the oil drippings from the bearings and cranks. On the bedplate is bolted the frame, which is cast in one piece, vertical ribs being provided in place of throughbolts to take up the working stresses. The elimination of throughbolts allows a narrower frame to be used.

Large openings at the side of the frame afford access to the cranks; these openings are fitted with sheet-steel doors of much lighter weight than the usual cast-iron covers, which reduces the labor of removal for inspection. Between the doors are small ports that enable the bearings to be observed while the engine is in operation, as well as assist in maintaining the frame at a low temperature by permitting a breathing action.

The main bearings follow the lines of those employed on the McIntosh & Seymour stationary Diesel, being of two-piece construction, and lined with white metal. Unlike the stationary engine, no oil well is used, since the oiling is accomplished by stream lubrication. The oil after passing through the bearing drips to the bottom of the bedplate and is drained to one end of the engine. The lower half of the bearing shell, seated in a machined housing on the bedplate, is half-round and can be removed by lifting the shaft slightly and then rotating the shell. The upper half is babbitted at the ends only, as the end surfaces are amply strong to withstand the lifting action of the shaft due to the acceleration of the rods and pistons. The shells are provided with oil grooves and are beveled at the side partings.

Both ends of the connecting-rods are of the marine type and both the bearings or pin boxes are of cast steel, tinned and babbitted. The fact that this is possible on the gudgeon-pin box is probably due to the location of the pin at some distance from the piston head. All McIntosh & Seymour engines have this feature, and no piston-pin trouble has been attributed to it.

The wristpin is ground on the pin bearing surface and has both ends resting in straight bosses, being held by setscrews. The pin is lubricated by means of a V-groove on the surface of the piston. An oil line leads from the oil pump through the cylinder wall, and the pump is timed with the engine piston so that at each piston stroke a jet of oil is deposited in the V-groove on the piston. From the groove a channel leads through the pin boss and the pin, allowing the oil to reach the bearing. This has proved satisfactory with the stationary Diesel and insures positive oiling of the pin.

The piston is of one-piece construction and is fitted with eight rings, all of which are located around the upper end. The head is reinforced by six radial ribs, and the barrel is strengthened with four girth ribs. No cooling of the piston is contemplated other than natural air circulation. Experience seems to prove that cooling is unnecessary with pistons under 20 in. in diameter. The top of the piston is concave, which feature is claimed to assist in mixing the oil and air charge and to improve combustion.

The cylinder is of cast iron with a bolting-down flange at the base. Into it is pressed a liner that is machined all over, as required by the Marine Underwriters. The cooling water enters the jacket at the bottom, leaves through passages in the top flange and then flows through the cylinder head. The joint between head and cylinder is of the usual male-and-female type. As a further aid in keeping the joint water-tight, rubber tubing is used to form gaskets around each of the water passages as well as around the cylinder bore. With this arrangement any leaking water betrays itself by flowing out of the joint rather than into the cylinder bore.

The cylinder head is a round casting provided with openings on the top for the admission, exhaust, fuel and air-starting valves. The fuel-valve cage is seated in a bushing pressed into the head, this design insuring better cooling of the valve cage and providing a better cooling space in the head. Both the admission and the exhaust passages are on the same side of the engine. The exhaust header is of cast iron and is in six water-cooled sections. The air header consists of a flanged elbow to which is connected a short section of pipe slotted on the sides and closed at the bottom.

The admission and exhaust valves, which are of the same dimensions and are interchangeable, are mounted in cages, as shown in the sectional views of the engine cylinder in Fig. 2. The cages are of cast iron and have no water-cooling cavities or removable valve seats. The valves rest in long sleeves, the valve springs being placed between the sleeves and the outer or free ends of the valves. No dashpot or spring cap, as it is at times called, is used. The valves have steel stems on which the cast-iron heads are cast. The fuel valve is of the familiar Hesselmann design. Its valve cage is in two parts. The upper, containing the valve spring and dashpot, can be removed without disturbing the lower half. The valve is actuated by a rocker *A*, Fig. 2, that drives a short rocker or dog *B*, one end of which bears on the valve-stem nut *C*. The rocker *A* has hardened steel pins on the ends which can be adjusted to give the required roller clearance, and is driven from camshaft *D* through the reach rod *E*.

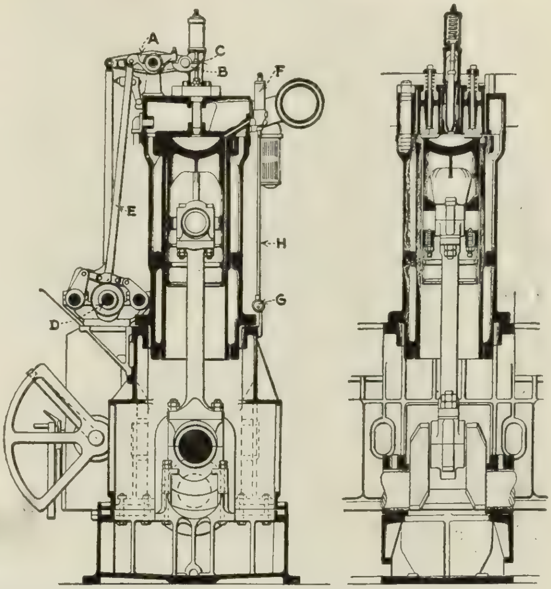


FIG. 2. TRANSVERSE AND LONGITUDINAL SECTIONS THROUGH CYLINDER

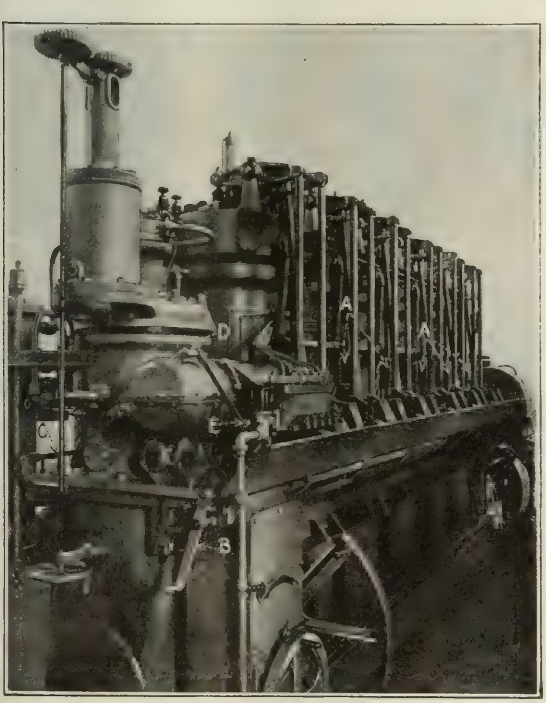


FIG. 1. SHOWING THE CAMSHAFT SIDE OF ENGINE

Compressed air, stored in a steel tank at a pressure of some 1000 lb. per sq.in., is used in starting the engine. The starting valve is controlled by a push-rod from the camshaft and is provided with an arrangement whereby it will not open in starting if the cylinder contains a charge of air or combustibles higher in pressure than the air in the starting tank. The push-rod has a spring-loaded cylinder *A*, Fig. 1, near its lower end. If the pressure in the engine cylinder is too high, the upward travel of the lower end of the rod will merely compress the spring inside the cylinder, without moving the upper end of the rod and the valve will not open; but as soon as the engine-cylinder pressure drops, the upper end of the rod begins to function. This is of special value when the boat is maneuvering, as frequently the air starter is thrown in before all the cylinders have been cleared. The air from the bottles is throttled to 150 lb. per sq.in. before entering the starting valve.

A relief valve *F*, Fig. 2, is placed on each cylinder and acts automatically. It is also used as a compression relief at starting. The lever *B*, Fig. 1, is pulled over, thus turning the shaft *C*, which extends the full length of the engine. This shaft, as shown in Fig. 2, carries an eccentric *G* from which a rod *H* leads to the relief valve on each cylinder. Thus, turning the shaft *C*, Fig. 1, opens the relief valves and decreases the resistance and so facilitates starting.

The valve rockers for the various valves on each cylinder fulcrum on a rocker shaft supported by two pedestals on the cylinder head, as may be seen in Fig. 1. In removing a valve cage, the entire rocker assembly is unshipped. Since the engine is reversed by lifting the push-rods off the cams, moving the camshaft endwise to bring a second set of cams into position and then lowering the push-rods, there is a period during the shifting when the valve-rocker push-rods are no longer in contact with the cams. It becomes necessary to support the rods during this interval, and that is accomplished by the arrangement in Fig. 3, which shows details of the valve rockers, push-rods and cams. A lever *A* is pivoted at the edge of the cylinder head and its upper end engages a roller *B* on the rocker-arm. A spring-loaded link *C* connects the lever *A* to the valve push-rod *D*. While the engine is running, the lever *A* is not in contact with the roller *B*, being held in position by the link *C*, which causes the lever to rock slightly as the rod *D* rises and falls. When the cams are to be shifted and the push-rods are raised clear of the cams by the movement of the reversing gear, this lever *A* is pulled into contact with the roller *B* by the action of the push-rod *D*, the lower end of which is swung to the right by the turning of the shaft *E* carrying the arm *F*. In reversing, the admission, fuel and exhaust push-rods are all moved to the right, while the starting-valve push-rod *G* is moved to the left by the swinging of the arm *H* on the shaft *I*. This is done in order to clear the cams as the latter are shifted along with the camshaft *J*. As soon as the cams are in the new position, the push-rods are dropped onto the cams that are then under their respective rollers. The camshaft is driven from the engine crankshaft by a set of two-to-one spur gears.

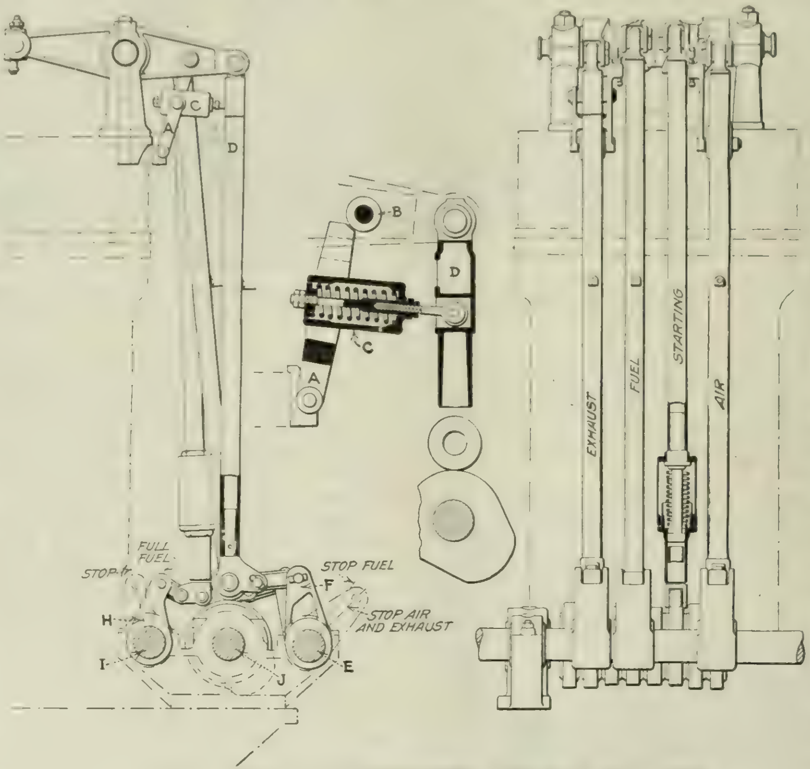


FIG. 3. DETAILS OF ROCKER-ARMS, PUSH-RODS AND CAMS

Two sets of cams are provided for each cylinder and are arranged in the following order on the camshaft—exhaust, fuel, air-starting and admission. They are made of cast iron chilled on the contact surfaces. The noses, or high points, of the admission and exhaust cams are finished to accurate measurements, while the fuel cam has an adjustable steel nose by which the fuel-valve timing can be altered.

The reversing and control gears are placed at the forward end of the engine, as may be seen in the foreground in Fig. 1. When the reversing wheel is in neutral position, the engine is set for running ahead or astern by rotating the wheel twice. This movement shifts the valve push-rods from contact with their cams and slides the camshaft horizontally, bringing the proper cams under the push-rod rollers. The mechanism whereby this is accomplished is outlined in Fig. 4. The handwheel *A* is keyed to a short shaft *B* that carries a bevel pinion *C* meshing with a bevel gear *D*. The bevel gear is keyed to a shaft *E* that carries a spur pinion *F* which meshes with a rack *G*. The shaft *E* also carries at one end a crank *H* connected by a rod *I* to an arm *J* keyed to the reversing shaft *K*. Turning the wheel *A* therefore swings the arm *J* upward to the left and so rotates the reversing shaft *K*, which is the shaft marked *E* in Fig. 3. This action lifts the valve push-rods out of contact with their cams. The same movement of the wheel *A* that lifts the push-rods forces the rack *G* downward by rotating the pinion *F*. The upper end of the rack slides in guides and is formed with a slot *L* in which moves a roller fastened to the lower end of the lever *M*. The upper end of the lever, which is pivoted near the middle engages a collar fastened to the camshaft *N*. As the rack is lowered, the roller slides in the vertical part of the rack slot without any transverse motion; but as soon as it strikes the inclined part of the slot it is moved to the right, throwing the upper end of the lever *M* to the left. This movement slides the camshaft endwise to the left, thus bringing the second set of cams under the valve push-rods for going ahead. This shifting occurs when the wheel *A* has made one revolution. A second turn of the wheel swings the crank *H* through the second part of its rotation, thus bringing it and the reversing shaft *K* back to their original positions, with the push-rod rollers resting on the go-ahead cams.

With the go-ahead cams in position to act on the push-rods, starting is accomplished by pulling down the control lever *O*, which is keyed to the shaft *P* and has a pointer that moves over the face of the graduated quadrant *Q*. At the inner end of the shaft *P* is a short crank connected to the lower end of the rod *R*, the upper end of which is connected to a crank on the shaft *S*. This is the same shaft as is designated by *I* in Fig. 3. When the lever *O*, Fig. 4, is pulled down to the bottom of the quadrant, or to the point marked *start*, the shaft *I*, Fig. 3, is rotated and the lower end of the push-rod leading to the air-starting valve is thrown into engagement with the starting cam on the camshaft, with the result that air is admitted to the cylinders of the engine, causing it to start.

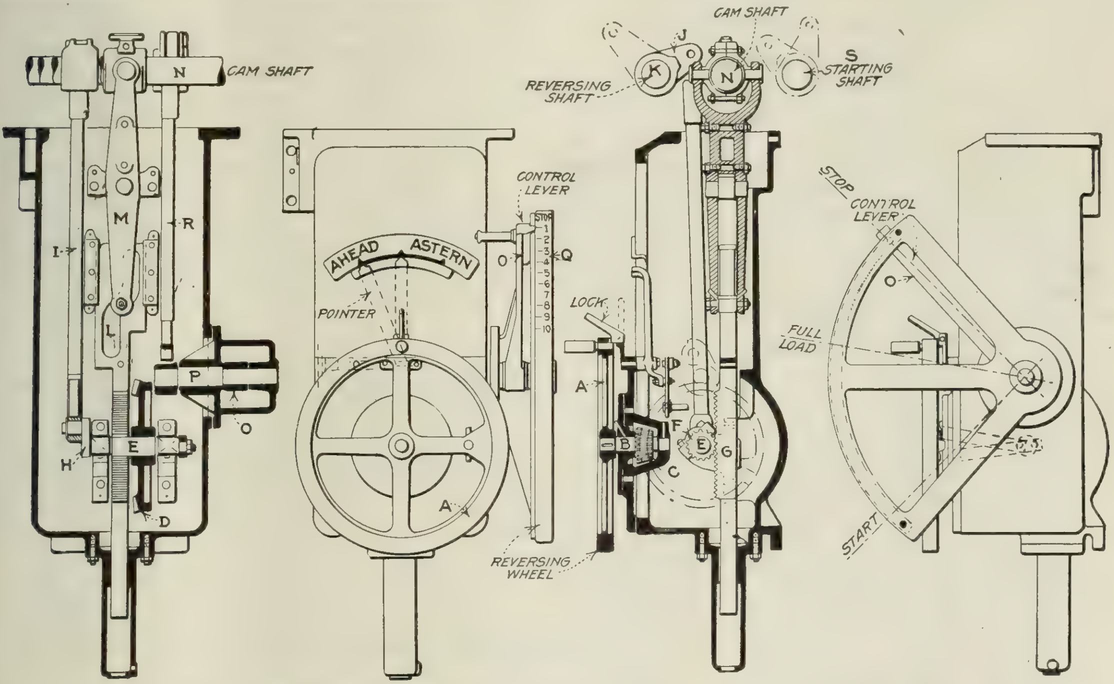


FIG. 4. ARRANGEMENT OF THE REVERSING GEAR AND CONTROL MECHANISM

There is a connection between the shaft *I*, Fig. 3, and the shaft that drives the fuel pumps, so that when the air-starting cams are thrown into action the stroke of the fuel pumps is reduced to zero and no fuel can enter the cylinders. As soon as the engine has turned over a few times with the air, the control lever *O*, Fig. 4, is raised to the middle of the quadrant or the full-load point. This movement throws the starting-valve push-rod out of contact with its cam and at the same time shifts the fuel-pump shaft so that the pump delivers a full-load oil charge to the cylinders. The control lever is then slowly raised to the proper running position for the load carried, this movement producing a corresponding decrease in the fuel charges. When the control lever is moved to the stopping position, or the top of the quadrant, the fuel delivered by the pump becomes zero. The reversing wheel and the control lever are interlocked so that the reversing wheel cannot be shifted until the control lever is raised to the stopping position; furthermore, the control lever cannot be shifted to the starting or running position until the reversing action is complete.

The stroke of the fuel pump is varied to regulate the amount of fuel entering the engine cylinders. The pump has six plungers, one for each cylinder, mounted in a cast-iron block that also contains the discharge and suction valves. The plungers are driven by six eccentrics mounted on a short shaft geared to the engine camshaft through a clutch. The eccentrics are set on their shaft at an angle with the shaft axis, so as to allow the eccentrics to be moved to a position that gives zero throw to the plungers. The pump is equipped with an overspeed governor of the ordinary type mounted on an extension of the pump shaft. This governor, acting through the bell crank *D*, Fig. 1, moves the shaft *E* through a slight angle. The shaft *E* extends into the pump casing below the suction valves, and its angular movement raises the suction-valve stems and thereby opens the suction valves during the complete pump cycle. This governor acts only in case of overspeed.

The air compressor is placed at the front end of the engine and is driven by an overhung crank on the engine shaft. It is supplied with a pressure and volume regulator, shown in the upper foreground in Fig. 1. The regulator is a cylinder connected to the low-pressure air cylinder and contains a piston that is raised and lowered by turning a handwheel. The movement of the handwheel is transmitted to the piston by the vertical rod and the gears at the top of the regulator. By the proper displacement of this piston the low-pressure cylinder volume is altered to give any desired high-pressure discharge pressure. Some such an arrangement is highly desirable on all Diesels, since the injection air pressure should bear a constant ratio to the fuel charge deposited in the fuel valve.

The cooling of condensing water in a pond, a spray cooler or through a cooling tower, is obtained in three ways: First, by radiation, which is practically negligible; second, by conduction of absorption of heat by the air, which may vary from one-fifth to one-third of the entire effect, and third, by evaporation, which is the chief factor.

The Electrical Study Course—Inductances Used on a Three-Wire Generator

Shows how inductances used in connection with alternating current change the conditions that would exist if resistances were used for balancing. Briefly reviews the properties of inductances and introduces the fact that direct and alternating currents can be transmitted over the same conductors at the same time.

IN THE preceding lesson it was shown that, theoretically, a three-wire system could be operated by replacing the machines of a balancer set with two equal resistances whose value was very low as compared with the resistance of the load, but that such a method was impracticable on account of the large loss in the resistances. It was stated that the use of inductances in place of resistances, and their connection to the slip rings of a three-wire generator instead of to its direct-current brushes, would cut down the large waste found to exist in the case of the resistances and yet allow the unbalanced current to flow freely from the neutral to either outside wire.

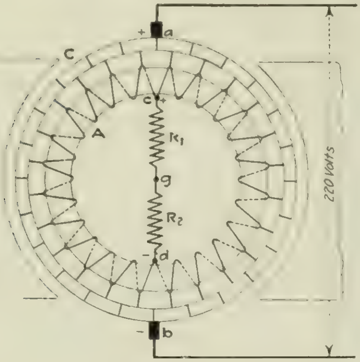


FIG. 1

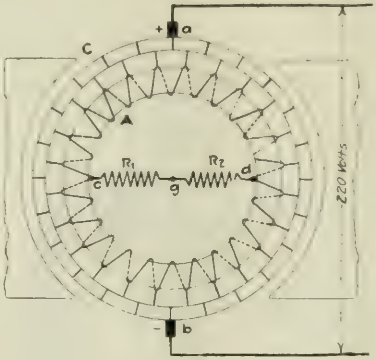


FIG. 2

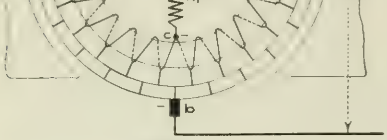


FIG. 3

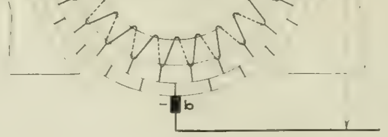


FIG. 4

FIGS. 1 TO 4. SCHEMATIC DIAGRAMS OF A RING ARMATURE WITH A RESISTANCE CONNECTED TO OPPOSITE POINTS OF THE WINDING

To understand the principle upon which the apparatus operates, refer to Fig. 1, in which *A* represents the armature of a generator, *C* its commutator, and R_1 and R_2 two equal resistances connected to the armature winding at *c* and *d*. For the time being assume that these resistances revolve with the armature. In the position shown there will be a voltage of 220 volts across *cd* and current will flow through R_1 and R_2 from *c* to *d*. However, when the armature has turned through one-quarter of a revolution R_1 and R_2 will have assumed the position shown in Fig. 2. As explained at the time that the principle of operation of generators was under discussion, there will be no voltage across *cd* when they are in the position shown, and consequently no current will flow through R_1 and R_2. When the armature has turned through another quarter revolution, the conditions will be those of Fig. 3. It will be seen that 220 volts again exists between *c* and *d*, but that *c* is now negative and *d* positive, and that the current through R_1 and R_2 will therefore be from *d* to *c* instead of from *c* to *d*, as was the case in Fig. 1. When the armature has passed through another quarter turn the resistances will have reached the position shown in Fig. 4, which is similar to Fig. 2, and under the conditions of which no current flows through R_1 and R_2. When a complete revolution has been made, we again have the conditions of Fig. 1.

From the foregoing it is evident that the direction of the current through R_1 and R_2 is constantly reversing and the voltage across *cd* continually varying from 220 to zero and back to 220 in the opposite direction. That is, an alternating current flows through R_1 and R_2. If the resistances of R_1 and R_2 are small, the current through them will be great, just as in the case of direct current; but if in place of resistances we use inductances, the current may be made very small. This leads to a consideration of what an inductance is. As a matter of fact the discussion comes within the province of the subject of alternating currents, and the fundamental theory will therefore not be gone into at this time, the discussion being limited merely to the manifestions observed without giving the reasons therefor.

Suppose that we have a piece of copper wire whose length is 100 ft. and whose resistance is 0.1 ohm, and that it is stretched out straight. If 220 volts direct current were applied to its terminals, the current that would flow would be $\frac{220}{0.1} = 2200$ amperes. If 220 volts alternating current were applied, we would have practically the same result; that is, it would be immaterial whether direct or alternating current were used. Suppose now, however, that the same piece of wire is wound into a spiral, such as that shown in Fig. 5. Its resistance will remain the same and if connected to 220 volts direct current it will take 2200 amperes, as before, but if connected to 220 volts alternating current it will be found to take a much smaller current. Just how much smaller depends on the number of turns, their diameter and the size of the wire. If the wire be wound on an iron core as in Fig. 6, the effect will be greatly augmented, resulting in a much diminished value of current. Thus a coil of wire that would take 1000 amperes direct current might take only 5 amperes when connected to an alternating-current source of the same voltage. We cannot stop to investigate the reasons for this behavior, but will have to accept it as being a fact. Any coil of wire such as that described, is known in alternating-current practice as an inductance and is said to have a certain number of henries of inductance, in the same way that a resistance is said to have a certain number of ohms of resistance.

Suppose now that we replace the resistances R_1 and R_2 of Figs. 1 to 4 by inductances L_1 and L_2, as shown in Fig. 7. These inductances may have the same resistance as R_1 and R_2 had, and yet will take only a very small fraction of the current taken by them. Should any source of direct current, however, be connected across L_1 or L_2, a large current could be made to flow even by a small voltage.

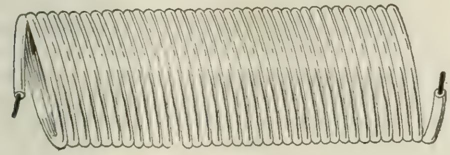


FIG. 5

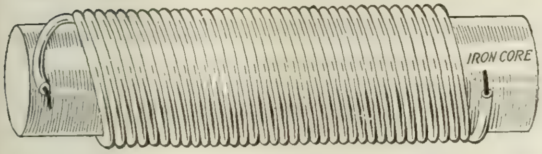


FIG. 6

FIGS. 5 AND 6. TWO TYPES OF INDUCTANCE

We now come to a second unfamiliar proposition; namely, that an alternating current and a direct current can flow through the same conductor at the same time. This statement also will have to be taken on faith for the present as being so without any explanation of it. The fact is that if we were to impress an alternating-current and a direct-current source upon an inductance simultaneously, the former would be limited by the inductance, but the latter would be limited by nothing except the resistance of the inductance. As a matter of fact, this is the condition that exists in the inductances L_1 and L_2 when they are made use of in connection with a three-wire system.

To make this clear suppose the direct-current brushes a and b of the generator in Fig. 7 to be connected to the outside wires M_1M_2 of a three-wire system that has the same load on both sides, so that the resistance from M_1 to N is the same as that from N to M_2. It is evident that under these conditions the voltages E_1 and E_2 will be the same, each being 110 volts. Since the inductances L_1 and L_2, Fig. 7, are equal, the voltage from d to g equals that from g to c. When the armature is in the position in the figure the voltage from d to g or g to c is one-half of 220 volts, or 110. If the coils were in the position of the resistances in Fig. 2, there would be no voltage cross cd, but there would be one of 110 volts from a to d, d to b, b to c and a to c; consequently the voltage from a to g or b to g is again 110 volts. It is a fact that the voltage from a to g or from b to g is always one-half that from a to b irrespective of the instantaneous position of L_1 and L_2.

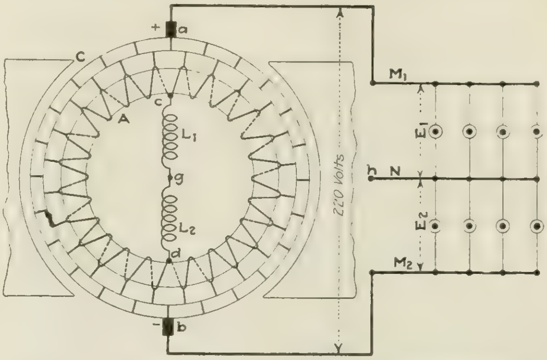


FIG. 7. SCHEMATIC DIAGRAM OF A THREE-WIRE GENERATOR

How this fact is made use of to create a three-wire system and how its functioning depends upon simultaneously transmitting both direct and alternating currents through L_1 and L_2 will be taken up in the following lessons.

In the preceding lesson the problem given consisted in finding the value of the voltages E_1 and E_2 in a system such as that illustrated in Fig. 8, if the load at X consists of 50 lamps of 150 ohms each and that at Y of 30 such lamps, if R_1 and R_2 each have a resistance of 0.5 ohm. The resistance of the lamps in multiple in load X will be the resistance of the individual lamps divided by the number in parallel; if R_x represents this resistance, we have $R_x = \frac{150}{50} = 3$ ohms. In like manner if the resistance of the lamps in parallel in load Y be R_y we have $R_y = \frac{150}{30} = 5$ ohms. The total resistance across AN is the multiple resistance of X and R_1, and if R_a be made to represent it, we have $R_a = \frac{1}{\frac{1}{R_x} + \frac{1}{R_1}} = \frac{1}{\frac{1}{3} + \frac{1}{0.5}} = 0.4286$ ohm.

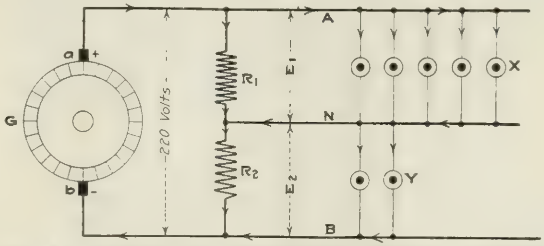


FIG. 8. DIAGRAM OF THREE-WIRE SYSTEM OBTAINED FROM TWO RESISTANCES

Similarly, if the resistance across NB is R_b we have $R_b = \frac{1}{\frac{1}{R_3} + \frac{1}{R_4}} = \frac{1}{\frac{1}{5} + \frac{1}{0.5}} = 0.4545$ ohm. Then the total resistance of the circuit is $R = R_a + R_b = 0.4286 + 0.4545 = 0.8831$ ohm, and the total current will be $I = \frac{E}{R} = \frac{220}{0.8831} = 249$ amperes. The volts drop across any circuit is equal to the resistance of the circuit times the current in the resistance; this gives $E_1 = R_aI = 0.4286 \times 249 = 106.8$ volts and $E_2 = R_bI = 0.4545 \times 249 = 113.2$ volts.

It was further required in the problem to determine the capacity of the generator G required to supply the power to the system. The power output of the generator would be the current supplied by it times the volts at its terminals; that is, the watts $W = EI = 220 \times 249 = 54780$, or $\frac{54780}{1000} = 54.78$ kw. The generator would therefore have to be of a capacity as near this valve as could be secured, probably 60 kilowatts.

A generator is to supply a plain two-wire system with power. The load consists of 500 fifty-watt 110-volt lamps, and is situated 200 ft. from the generator. What would have to be the capacity of the generator? What size rubber-covered wire would be required for the mains? How much would the generator have to be overcompounded at full load to maintain constant voltage at the lamps?

Geared Turbines for Marine Propulsion

BY LIEUT. CHARLES H. CAMP, U. S. N. R. F.

WHEN the great demand came for ships to meet the war emergency, one of the important problems presented was the prompt securing of propulsion machinery. To obtain an adequate number of reciprocating engines in any reasonable time was impossible. In spite of the fact that none of the companies manufacturing turbines for ship propulsion had adequate special departments (two of them had no such departments at all) for large production, or a sufficient number of men with the necessary specialized experience to handle such production, the geared turbine offered the only solution to the problem.

Anyone with experience in any line of production understands the multitude of problems presented by the manufacture of any new article or comparatively new article, no matter how simple that article may be or how adequate the force of men, specially trained in that line, who are handling it.

What, then, can be said of such an intricate problem as the immediate production on a large scale of marine geared turbines, when there were so few men who had any experience to speak of in either the design, manufacture, installation or operation of them? Each one of these elements is vital to the success of the machine. In the beginning none of them were present completely, and individually only in isolated cases, if at all. If any person wishes to dispute this statement, let him ask himself how much he has learned the past year and how much he is still learning, or, if he thinks himself proficient in his particular part, if he had the coördination of the other elements.

The truth is that when the demand came none of the companies had enough ships equipped or for a long enough time to have formed any definite opinion regarding what problems had to be met or how successfully those known were being met. Doubtless none of the companies relished the idea of launching out on a sea for which it had so few charts and such an inadequate force of officers and crew.

Naturally, many mistakes were made and a great amount of prejudice has been created against the marine turbine. Also, there is a reactionary element among marine engineers, as in all other walks of life, and this element seizes avidly on every occasion that offers half a chance to criticize the turbine. Many of them, without ever having operated a turbine set, express the opinion, "Give me the old reciprocating engine; none of your windmills for mine."

Most of the criticism of the marine-turbine unit is undeserved. The engineer who has the foregoing opinion will soon suffer the fate that any nonprogressive must meet. Fortunately, the marine engineers are a highly intelligent and progressive class of men. For the marine turbine has come to stay. In space occupied, weight per horsepower, economy of fuel consumption, upkeep, simplicity and flexibility, the marine geared turbine is now far superior to a reciprocating-engine installation.

With the problems that are to be met and the methods of meeting them pretty well understood and becoming better understood every day, there will soon be the same marked superiority of a marine turbine set over a marine reciprocating unit as now exists in a turbine over a reciprocating engine in central stations on land. Indeed, considering the factors enumerated, an official of one of the large steamship companies, nearly all of whose ships are turbine equipped, makes the assertion that even if they had to scrap the entire turbine set once a year, it would pay to use them in place of reciprocating units.

There is little to be said when the numerous variations of turbines aboard ship are considered, such as compounding, either by one high- and one low-pressure turbine, or two high- and one low-pressure or a multiplication of these combinations on one, two or three propellers, or divided slow turbines, or electric drive with current supplied by turbo-generators in an infinite variety of ways and all with a flexibility of control and manipulation impossible with any other present type of unit. In these matters the turbine has no rivals. In economy the Diesel engine is the only unit offering competition. But the superiority of the Diesel engine in this respect is overcome by the many difficulties besetting its operation and upkeep in its present state of development.

A good many of the problems in marine geared turbine sets have arisen from a perhaps unconscious desire on the part of the builders to emphasize the preeminent advantages of their unit—small weight and space occupied per horsepower. In any event it is a fact that foundations, turbines and gears have been built too light and too compact for proper and necessary periodic inspection. They can be built of ample strength and size and of a design to permit inspection of all parts, the obtaining of bearing clearances, etc., and still retain their advantages to a marked degree.

Foundations of insufficient strength under turbines, gears and main thrust bearings have led to an endless amount of trouble due to the ship's "weaving," causing independent movements of the different elements, the gears taking a movement independent or in excess of the turbine, or, where an independent main thrust is used, a change in relative positions with that element. These movements result in misalignment, of course, and not only are excessive stresses set up in all parts, but the perfect meshing of the gear teeth is disturbed, decreasing the area of tooth contact (already too small) and resulting in extreme tooth pressure. Extreme tooth pressure, whether due to misalignment or original design, not only forces out the oil, thereby eliminating lubrication and causing excessive wear, but creates adhesion of the pinion and gear tooth surfaces in contact, and when separation of these surfaces occurs small particles of the metal are pulled loose. This last effect is the so-called "pitting." It is cumulative, as each particle pulled loose decreases the area of effective tooth contact.

Builders are now installing very heavy, well-braced foundations and adopting flexible construction to compensate for "weaving" and for the change in alignment that occurs when a ship is loaded or light.

IMPROVEMENT IN METHODS OF LUBRICATION

Methods of lubrication are being steadily improved. The old direct-pressure system was faulty, not only on account of the great rapidity, constant movement and number of times a given unit of oil was whipped around its circuit in a given time, but because periodic "dry spells," however brief, were constantly occurring over all parts of the system, due to air bubbles and the pulsations of the pump. Methods of application of the oil to different parts have received the attention their importance demands. Methods of settling, filtering and heat-treating of oil are also provided in modern installations. The manufacturers of lubricating oils have made exhaustive studies and tests on grades of oil best suited to the work.

An all-important factor in the success of any machinery is in its care and operation. At the beginning of the war a very limited number of marine engineers had any experience with turbines. A tremendous amount of credit must be given to these engineers, not only for their quick grasping of the turbine and for their adaptability, but for their great courage and patriotism in taking assignments on turbine-driven ships under all the circumstances—experimental stage of construction and installation, meager knowledge and at that time an almost total lack of instructive literature or even blueprints to show what made it tick—when it was a mighty dangerous proposition and one requiring high courage to sail the seas with most reliable, tried and true and familiar machinery.

The manufacturers must come to realize the necessity of more instructive literature. The United States Navy, which leads the world in its instructive courses and literature for its officers and men, has entered with its traditional spirit and efficiency into the undertaking of turning out more men and more competent men for operating turbine-driven ships. An exceptionally fine course is provided at the Carnegie Institute in Pittsburgh, combined with study at various turbine factories. The Shipping Board is also working along educational lines.

ACCESSIBILITY FOR INSPECTION IS VITAL

But the most efficient operator is going to be seriously handicapped and sudden serious breakdowns will continue to occur unless the manufacturers wake up to the fact that they must make their units more accessible for the inspection of parts and the taking of clearances. As it is, a turbine must be completely dismantled to inspect blading, diaphragms and other internal parts; the turbine bearing clearances and in most cases the turbine thrust clearances cannot be ascertained without a considerable job of dismantling; there are always six or eight bearings in the gear case that cannot be examined for clearances or condition without a prohibitive amount of dismantling; alignments also require a prohibitive amount of dismantling to check up, and in many types the same is true of flexible couplings, emergency governors, etc. A machine hard to inspect or test is seldom inspected or tested. In nothing more than in machinery is it truer that "a stitch in time saves nine." The way marine turbine sets are constructed at present, a complete failure of a part is usually the only indication that it is not in perfect condition. The engineer or inspector from the United States Navy, Shipping Board or turbine factory makes inspections every time a ship is in port, but on account of the present type of construction a great many important features that should be included in a thorough inspection have to be left to chance or insufficiently surmised from evidence shown by other parts.

Turbine manufacturers must consider gains in economy on marine sets the same as on land. There are even reciprocating-engine ships using a superheat of 200 deg. F. This should be used on all turbine ships. Pressures, vacuum apparatus (this has reached a high state of achievement), nozzle areas, stages, efficient steam separators, maintenance of high feed-water temperature, proper jacketing and prevention of the use of excessive steam for steam seals are all matters as easily taken care of aboard ship as on land and will gain the same marked superiority in economy.

INSURING DEPENDABILITY AND ECONOMY

As a matter of safety two turbines cross-compound are safer than the single unit and make reaching a port under steam almost a certainty. With more substantially constructed foundations, gears and turbines, proper safety devices and better-trained operators the dependability of a marine turbine set is very good. With the elements affecting economy taken care of, their economy is unapproachable by any other steam unit. They are inherently the most flexible, and with an engineer who understands his turbine, the handling of the ship is every whit as good as, if not better than, with a reciprocating unit. With proper facilities provided for an easy, thorough inspection; with gears built with teeth of proper pitch and angle, properly designed and correctly cut; with the tooth pressure kept in proper limits and with proper oil and methods of handling and applying it, the marine geared turbine set will show as marked a superiority over reciprocating units in upkeep and delays due to breakdowns as they do on land in both this feature and in economy. In space and weight per horsepower there is no comparison.

The turbine companies, whether through lack of coördination, ultra-conservatism or lack of courage of their convictions, are not going ahead as fast as they can on lessons they have already learned and problems they already know how to meet. Yet it is a fact that right now they know how and can build and will ultimately build a unit that will rank head and shoulders above any other type of marine steam unit, viewed from any angle, except in the multiple-maneuvering requirements of battleships, for which the electric drive with current from turbo-generators is best suited.

Care of Flue-Gas Treaters

By J. M. Wauchope*

The system of precipitation of solids from flue gases as developed by Dr. F. G. Cottrell has been described in various magazines, therefore this article will be devoted to the practical operation of such plants as viewed from the operator's standpoint.

As is well known, the principle of operation is the passing of the gases to be treated through a strong electrostatic field, the field being commonly produced by suspending wires in the center of vertical iron pipes through which the gases are passed. The wires are charged negatively and the pipes positively and grounded. The voltages in common use run from 20,000 to 50,000, very seldom higher, depending on the distance between the electrodes and the conditions of the gas.

The current to produce the field must be direct, as alternating causes the field to reverse, resulting in smaller catch. The high-tension direct current is obtained by rectifying alternating current of suitable voltage by means of a mechanical rectifier.

Of the two systems of electrical equipment in use, there is a divided opinion as to which is the better. The individual motor-generator set is used to a greater extent, but many plants are being installed using power direct from the power mains. The writer is at present operating plants using both systems, those using power direct from the mains giving far better satisfaction; in fact, some units of individual motor-generator sets were so unsatisfactory to operate that they were changed to the direct system.

With the motor-generator sets the snapping is much worse where the conditions in the treater are not good, as there seems to be a tendency to surge, which is largely absent in the direct system. In the direct system the power is taken from the mains through transformers, generally stepping down from 2200 to 220 or 440 volts. These transformers and the large system back of them seem to act as a cushion to smooth out the high-voltage surges caused by arcing or bad gas conditions in the treater. In cases where a very high resistance had to be used in the high-tension leads to the rectifier in order to operate with the motor-generator sets, by changing to the direct system this could be largely done away with and much better operation resulted. It is necessary in all cases, however, to have suitable choke coils in the alternating-current leads from the high-tension transformer for its protection.

It has been feared by some that in using the direct system there would be danger from high-voltage surges being reflected back to the power mains, but the writer is of the opinion that there is no basis for this, since the units operating this way have given absolutely no trouble and the operation is much better. The low-tension circuit between the two transformers is grounded through a resistance to drain off any static that might accumulate.

A suitable inductance in the direct-current circuit is a great aid to smooth operation in many cases where there is a tendency to snap, and especially with the motor-generator system. It has been contended by some that the inductance will lower the power factor, but the benefits are so large and the change in power factor so small that the former far outweigh the latter. The inductance is especially valuable in case of broken wires in the treater, or other severe arcing, as it smooths out the wave and protects the transformer from the surges. As the voltage in the treater should be carried as near the arcing point as possible, anything that aids in smoothing out the direct-current voltage wave is beneficial. Also, as large a percentage of the alternating-current wave as possible should be rectified. In the form of rectifier that has four arms in a set, there being two sets, the inductance allows these arms to be placed so that a larger portion of the wave can be rectified without snapping, which is conducive to more efficient operation.

A certain amount of resistance is necessary in the low-tension alternating-current circuit for ballast, in nearly all cases, as it tends to make smoother operation. The collecting brushes on the rectifier should be set as close to the revolving element as possible, so that power will not be wasted due to a large air gap. Operators should at all times see that the voltage is as high as possible for good operation, as it is liable to vary quickly with a change in gas conditions.

A gas that is too dense is not cleaned as well as one of the correct density. The pipes and wires should be cleared of all deposits before they become heavy enough to interfere with good operation. Air leaks into the treater should be watched for and the insulators inspected often. Of course if an insulator breaks down completely it is soon known. With some gases, if they become too dry, snapping will start, which can often be stopped by spraying water into the gases where they enter the treater, moisture being beneficial in some cases.

There is a tendency among some operators to take the milli-ampere charging current as an indication of the operation of the treater. However, this cannot be depended on, as the charging current will vary considerably, and yet the recoveries may be consistently good or just the opposite. The absence of a white snappy spark on the rectifier is an indication of good operation. The spark should be of a purple color and hiss rather than crackle.

Everything about the treater and station should be thoroughly grounded, as static charges have a way that is very surprising at times of collecting in places on ironwork. A heavy sheet-iron guard should be placed around the rectifiers, for they have been known to burst with startling results at times, and all the high-tension wiring should be inclosed by heavy grillwork.

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*Chief electrician, International Smelting Co., Tooele, Utah.

EDITORIALS

Installation Cost Versus Maintenance Cost of Electric Equipment

IT IS not as generally recognized as it should be that the cost of carrying on a suitable preliminary engineering study prior to making an electrical installation, with the object of obtaining the electric equipment best suited to the work to be done, is a good investment. The perfunctory selection of control and motor equipment may lead to a very unsatisfactory installation with its attending high maintenance costs. It is not enough that a motor or controller be of excellent construction and workmanship—they must also be designed for the duty they are to perform. Not infrequently installations that have been made at great cost for high-grade equipment have been failures because of improper application of the equipment, when, if a proper study of conditions had been made, a less expensive equipment suited to the work to be performed would have given excellent results. Improper applications of electric drives have led to expensive replacements of motors and control equipment, with the attending increased cost of installation, radical rearrangement of drives, etc., not to mention the loss in production due to interruptions.

On the other hand, there is the cost of maintenance to be considered. The cost of installation is a factor that can be determined with a fair degree of accuracy, but maintenance expense is very difficult to determine, since not only must the expense of keeping the equipment in running condition be considered, but also the loss in production due to interruptions; and in some cases an inferior product may result. An improper application of an electric drive always leads to high maintenance charges. If the controller is too light for the service requirements, severe burning at the contacts and excessive heating of the resistance are the results, and if not properly designed for the duty to be performed, the motor cannot function properly even if suited to the work, and thus the cost of upkeep of the driving medium is increased. Overloaded motors give all kinds of trouble and underloaded motors are inefficient.

There are two methods of maintenance: First, the kind that makes repairs only when forced to do so by a shutdown, which to say the least is expensive and unsatisfactory; second, the kind that keeps the equipment in operation, that gives the machinery a little attention each day, and locates and remedies the defects before they have time to develop trouble. There are cases where the direct maintenance cost of the latter may be more expensive than the former, but when compared with the increase in production obtained by the latter method, there is no comparison between the two. The latter means a practically continuous operation of the equipment, where the former leads to all kinds of expensive interruptions and dissatisfaction.

The installation of motor and controller in inaccessible places where they cannot be taken care of, just to economize in a little floor space, is false economy. If the attendant is to be expected to take care of the equipment, it must be placed where it can be given attention without excessive effort. If this is not done, it is immaterial how conscientious a workman may be, he generally gets disgusted with having to keep up machinery where he has to subject himself to all kinds of inconveniences to do so, with the result that the equipment is neglected.

In this period of reconstruction, when manufacturers are looking for ways and means of reducing cost and increasing production, the electric drive should be given serious consideration. If it is not properly selected, installed and maintained, it may mean the difference between a high cost and a low cost of production.

The Underpinning of Faith

AMERICA had only begun to fight when the armistice was signed. No one realized this more than Fritz himself. His moral sense was a minus quantity and his understanding of psychology was ludicrously inaccurate, but he still retained enough sense to appreciate that he was a beaten man and that to prolong the conflict was but to convert defeat into disaster and transform reverses into a rout. So he sent out the white flag and the crash of cannon ceased.

By that strategy he saved his face, and he cheated the Allies of the chance of punishing him as he deserved, of dealing with him as ungently as he had dealt with Belgium and of sending back to him with compound interest the devastation and death he had loosed upon a peaceful earth. But the military Frankenstein he had created was about to turn and rend him.

For America had more than two millions of men in France and millions more in training; ships were building to transport them; munition factories were just beginning to hit their stride; chemical plants were producing poison gases of a deadliness and effectiveness such as the Hun never dreamed; great bombing planes were being assembled, in preparation for the days when destruction should descend like hail on the Fatherland and the horrors of warfare be brought home to the willing worshipers of a swashbuckling sham.

A mighty machine was in motion toward the Rhine. From the days of its first faint stirrings at Seicheprey it had gathered speed and momentum until no organized resistance could stand before it. That machine was conceived, built and motivated by faith—the faith of the American people in the justice of their cause, the ability of their leaders, the strength of their own arms and the inexhaustible resources of their homeland. It was that quenchless faith which proved the undoing of the Hun and paved the way for the imperial skedaddle to Amerongen.

Behind that faith, what?

The power of the almighty dollar—the selfsame dollar that Europe had professed to regard as the American's god, that she liked to ridicule and yet that she never declined to take from tourists possessing greater generosity than good judgment. That was the material foundation for America's effort.

All the vast wealth of the nation was pledged to the furtherance of our activities in the war. Fortunately, we needed to use only a small part of it. But the intent and the promise were there. We were as one in the determination to spend the last red cent, if need be, to wipe the red smear of Prussianism from the face of the world.

The task is not ended. We have only partly completed the job. We have removed the menace of German domination, but we have not discharged our fighting forces. There is yet a great army abroad to be fed, clothed and brought home. There are the disabled to be cared for and trained for gainful occupations. There are camps and hospitals to be maintained. There are enormous war debts to be paid.

These are the reasons for the Victory Liberty Loan so soon to be launched. Our war expenses have not ended with the ending of hostilities. It was utterly impossible to dismantle in a day the titanic war machine that we had built. Therefore our expenses must continue.

The fifth loan is to finish a work nobly begun and splendidly carried forward. It is to redeem the pledge of the nation to see the whole affair through to a successful ending.

The job will not be properly done until the Victory Loan is fully subscribed.

Developing the Water Power of Maine

WHAT a pity that Maine does not occupy the geographical position of Massachusetts or Connecticut! With her abundant resources in water power she would exert a most favorable influence upon the industries of New England. But, after all it is perhaps well that this most northerly state on the Atlantic, far removed from the coal fields, has so many large rivers on which many hydro-electric stations may be built. It greatly adds to the cost of steam power to the people of that state because the charge to take coal from Hampton Roads to her ports is high.

A special investigation of Maine's water-power possibilities shows that 700,000 horsepower is available. Half a million is available on the Kennebec, Androscoggin and Saco; only half of this is now developed. The Kennebec will yield about 230,000 horsepower, though only 40,000 or about one-sixth is at present developed. The Androscoggin ultimate practicable yield is 160,000 of which 120,000 is already developed. The Saco can produce 50,000, and two-thirds of this is now developed. On the six great rivers of Maine fifty-five per cent. of the available power is developed.

The Public Utilities Commission for that state believe that existing plants, aided by storage, can meet the demands for power for several years to come. This is likely true, as unusually great storage capacity is available at a remarkably low cost. But many of the public utilities now producing and selling power are hard pressed to meet peak demands. To increase the station capacities for each of these companies doubtless would mean expenditures far in excess of the amount required to build a station and utilize some of the undeveloped power, distributing it over trunk lines to all the companies which need it. The commission touches upon this problem. How such a plan will be financed is a matter for the state and business to handle. There are several ways of doing it. The Kennebec is the great source of power for future needs in Maine, and storage upon it is to be had at low cost. It is of interest to know that engineers estimate that the average cost of developing the practicable resources is about one hundred dollars per horsepower. On the six great rivers, the Kennebec, Androscoggin, Penobscot, Presumpscot, Union and Saco, 79,000 horsepower increase may be had by storage regulation at the low average cost of thirty-four dollars per horsepower. If all suggested storage developments were made, there would follow an increase in primary power of 168,000 horsepower at a total cost of sixteen dollars per horsepower.

With such water-power resources, all possible of development at comparatively low cost, one may judge of the competition that such developments might give to the steam stations at tidewater. With storage regulation power can be transmitted to tidewater at from four to nine mills (six mills an average) per kilowatt-hour of primary power at the substation of the transmission line as against one and one-quarter cents per kilowatt-hour at the switchboard of large steam stations now operating at tidewater.

Peculiarly, the laws of Maine prohibit the exportation out of the state of power generated within the state. Thus Maine cannot tie in with other New England water-power systems. The commission says that other than railroads the total power generated by steam in Maine is but 230,000 horsepower. And Maine has not demand for anywhere near her total water power available. This should not, however, hold back development of her resources in power. She should sell it, reserving the right to curtail supply to without her borders for needs within as the demand rises.

Some interesting data on construction and operating cost of water power, with particular reference to Maine, are given elsewhere in this issue.

According to a newspaper item and credited to the *Great Lakes Bulletin*, the firemen on board ships seem to have a "snap." One paragraph is as follows:

> The daily routine of a man on watch consists merely of seeing that the fires are purple and the steam at the proper height before he relieves his man. From then on until his watch expires he merely has to maintain the required amount of steam up and watch his fires.

Maintaining a purple fire may be a sinecure, but we were under the impression that by the time a marine fireman had stood his watch and kept the steam pressure at the proper point and his fires in proper shape, he had done what might be considered a day's work.

The recent Mobile boiler explosion again emphasizes the pent-up energy in high-pressure steam boilers. The two boilers that exploded were fifteen and twenty years old respectively, and although repairs may have been made on them, it would seem that after such a period of service it would be advisable to reduce the working pressure somewhat and at the same time exercise greater care in the matter of inspection.

When we see some fellow take the floor every fifteen minutes at an engineers' meeting, we are reminded that a babbling stream has to spread itself considerably to make up for its lack of depth.

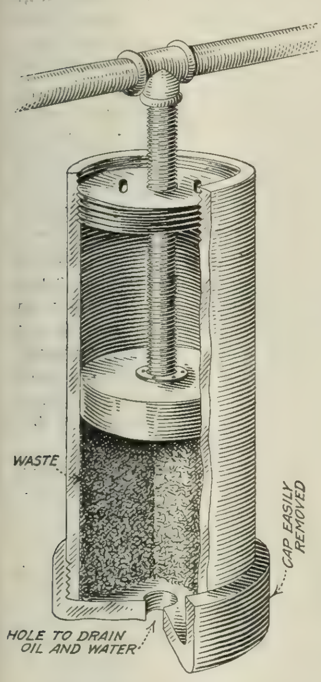
Most of us believe the thing that it is to our interest to believe. Witness the assertion of superior economy on the part of the central station as a power producer.

· Correspondence ·

How Dirty Waste May Be Cleaned

Waste that is used for wiping machinery generally becomes extremely dirty with use and is then thrown on the coal piles. A better way would be to collect the waste in a suitable covered can and, when a sufficient quantity has accumulated, place it in a strong solution of common soda and boil it. A large proportion of the dirt and oil will be removed, and a proper rinsing will make the waste ready for use again. A press for squeezing out the moisture in the waste can be made, as illustrated, from a piece of 5-in. pipe. The pipe is fitted with a drilled cap on one end and a plug on the other, and the plug is tapped for a threaded ½-in. rod fitted with a piston on one end and a tee on the other. The piston can be made of wood. The waste is put in the press and the plug is then screwed into the end of the pipe, and by screwing in on the ½-in. pipe, excess moisture is pressed out. To remove the waste unscrew the cap and force it out by means of the piston. **James M. Purcell.**

Richmond, Va.



PRESS FOR WASHED WASTE

Thermos-Bottle Principle Applied to Steam Cylinders

In the issue of Feb. 25, page 293, there was published a letter on "Thermos-Bottle Principle Applied to Steam Cylinders," in which the writer suggested that the jackets of cylinder-jacketed engines be connected to the condenser and radiation losses be thereby reduced. This idea was tested out very thoroughly in the laboratories of the University of Wisconsin some years ago. A compound condensing steam-jacketed engine was first carefully tested, both with and without steam jackets. Then the steam jackets were connected to the condenser and tests made at various vacua.

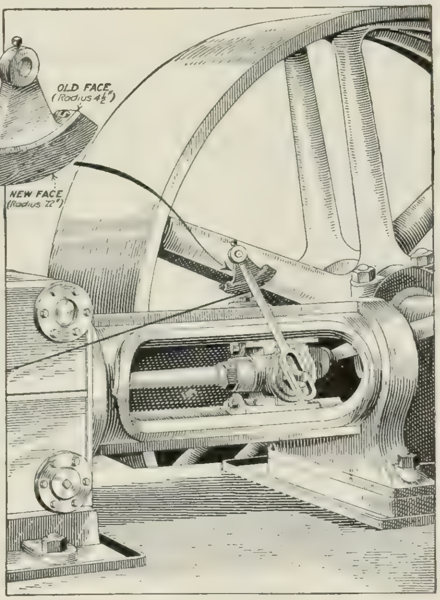
This vacuum apparently hadn't the slightest effect on the steam consumption. An extremely high vacuum pump was available and was connected to the jackets to produce high vacuum. Such vacuum had very slight effect on the steam consumption of the engine. It was therefore concluded that the use of the vacuum jacket had no effect whatever on the cylinder condensation, which is the serious loss in the engine, and further, that a perfect vacuum would be required to appreciably reduce radiation losses through the jacket space alone.

Such a vacuum cannot be obtained with an ordinary condenser. Furthermore, there would still be considerable radiation from conduction of heat through the metal cylinder heads, joints and ribs connecting the cylinder and jacket. These tests indicated clearly that nothing would be gained commercially by putting a vacuum on cylinder jackets. **A. G. Christie.**

Baltimore, Md.

Altering a Reducing Motion

Some time ago I bought an indicator and reducing motion in order to secure diagrams from my engines, but when I used it I obtained a diagram only 2½ in. long, which was too short. Using the rule of proportion, I find it to be 2½ : 4½ : : 4 : 7.2 in. Thus the 2½-in. card was made from a reducing motion, the face of which was 4½ in. from the center point.



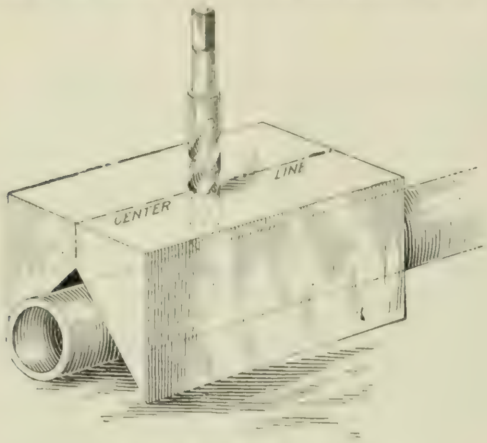
ALTERED REDUCING MOTION

A card 4 in. long would require a reducing motion having a distance of 7.2 in. from the center to the face. To obtain the proper travel of the indicator drums, I added a piece of wood, as shown in the illustration. This gave a card exactly four inches long.

St. Louis. Mo. **M. J. Merrell.**

Preventing a Drill from Slipping

Having a number of holes to drill in a pipe, I at first experienced some difficulty, as the drill would tend to slip. I then took a block of wood, cut a true V-shaped notch and placed it over the pipe. A line was drawn through the center of the block corresponding to the bottom of the V and a hole drilled on this line. Putting the drill through this hole brought it on a center line of the pipe and at the same time furnished a support for the drill, thus preventing it from slipping. Pipe of different sizes can be drilled with this same block.



GUIDE FOR PIPE DRILL

Richmond, Va. J. M. PURCELL.

Burning Fuel Oil in a Coal-Burning Furnace

Referring to page 411 of the Mar. 18, 1919, issue, and the short article relating to bagged boilers caused by burning fuel oil without change of furnaces, I would say that I have had two experiences of this kind, and from the many furnaces that have been changed to burn fuel oil in which the only alteration was to remove certain sections of the grates and place a baffle wall in the furnaces without any trouble whatever. I believe that the bagging in the instance mentioned was caused by the fact that at this particular point there was in this boiler a certain amount of scale or dirt that had collected directly over the bag.

In every case that has come to my notice, either with oil or coal fire, where a bag has developed, scale or dirt located at that point has been the direct cause, together with a too intense fire. A. E. WALDEN.

Baltimore, Md.

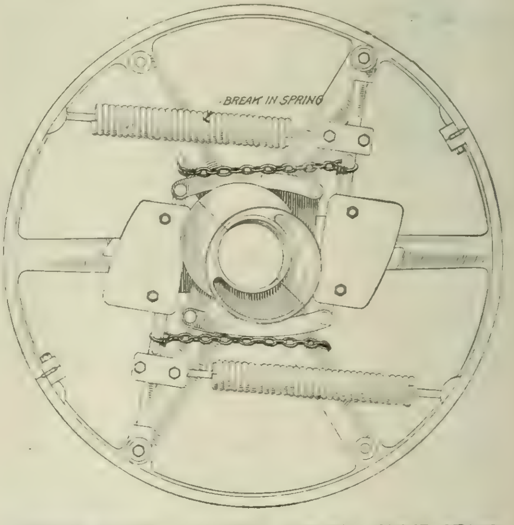
Engine Emergency Stunts

The editorial, "Helping the Other Fellow," in *Power*, Dec. 31, 1918, would no doubt result in benefit to progressive engineers if they would respond by telling about the stunts they have "pulled off" during their engineering careers. Many of them have good ideas which, if made public, would be of value to others and a source of gratification to the giver. As a starter I present the following:

The cutoff valve in the low-pressure cylinder of a tandem-compound engine broke in three pieces. As the accident occurred an hour before the peak load came on, something had to be done quickly because the other engines were too small to pull the commercial-lighting load. After giving up the situation as lost, the chief engineer disconnected the cutoff rod and used a chain to clamp the low-pressure valve firmly against the head end. This allowed steam to enter on the crank end. The engine was started in time for the show at the opera house at 8: 15 p.m. and lasted just 20 minutes after the show was out. At midnight the valve chest was opened up and the broken cutoff valves removed together with the stretcher rods. Then the main valve was replaced and ran without the cutoff valves for 9 days, until the new ones arrived. The engine not only ran better without the cutoff valves in the low-pressure cylinder, but pulled 30 kw. more load, or 210 instead of 180.

In another instance the governor spring broke on a shaft governor just as the afternoon peak came on, As we had no spring in stock, we were up against it. So the chief pulled his hair and, after cursing a little, ordered the chain again. The weight levers were chained securely to their inner stops, about as shown in the illustration, thus giving the engine maximum valve opening. The engine was run throttled this way for over a week to help out on the peak head.

A new engine had been promised for the winter load, but at the last minute word came that the deal had fallen through. The chief talked plain English and told the powers that be what could be expected in the way of poor service. Finally, the manager borrowed an engine from another plant that had just discontinued the use of four 125-hp. tandem units. The borrowed engine was connected up and running by the following Saturday night just in time to save the day.



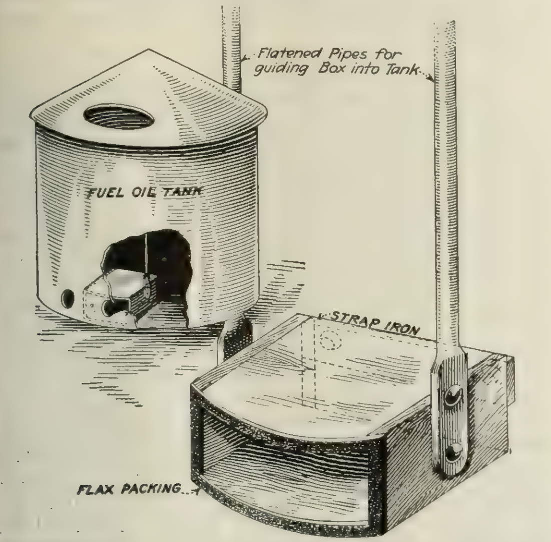
WEIGHT LEVERS CHAINED AGAINST INNER STOPS

In the meantime the engine that had been bought as junk was rebuilt and made a permanent part of the plant and was used to reduce the coal bill on Sundays, holidays and after midnight, when the load was less than 100 horsepower. So in the end the borrowed engine proved to be a good investment, as it saved over a ton of coal a day, or approximately 12 per cent. on the coal bill. WALDO WEAVER.

Franklin, Ohio.

Connecting an Oil Line to a Fuel-Oil Tank

A crude-oil tank, 20 ft. deep and 30 ft. in diameter had but one feed line going to the boiler oil burners, with the exception of a dangerous one that was connected to the water drain pipe of the tank. That, if used, might have put all of the boiler burners out of commission or carried water to the burners, as it is connected in the bottom of the tank.



SHOWING HOW THE HOLE WAS DRILLED IN THE TANK

The need of another oil line was evident, and the problem was solved by putting a 4-in. connection in the side of the tank at the bottom. Not more than two or three buckets of oil was lost by the operation, as a pan was used to drain crude oil back to a small tank into which the oil is discharged from the cars.

A wooden box was made, 14 in. square by 8 in. deep, with the face made to fit the curvature of the tank. The edges of the box that came next to the tank were lined with flax packing and held in place with nails driven well in so as not to hold the packing away from the tank. A piece of strap iron was then screwed to the back of the box, and two ⅝-in. holes were drilled and tapped through both. This plate was for the purpose of pulling the box up to the side of the tank by means of bolts extending from the outside.

Next, two lengths of pipe, each flattened at one end, in which two holes were drilled, were bolted one on each end of the box, so as to guide and let it down to the desired position in the tank. Corresponding holes were drilled in the tank to match the tapped holes in the box, so as to draw the box with flax packing tight against the tank. The holes in the tank were carefully drilled with an air drill running at slow speed so as not to cause heat or produce a spark, which would subject the oil tank to the danger of fire. As soon as each hole was drilled, a wooden plug was inserted.

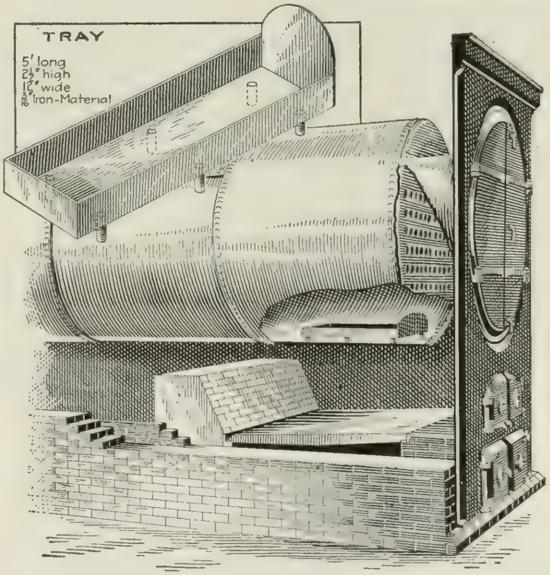
When all was ready, the box was lowered, through a manhole at the top of the tank, to its place corresponding to the holes drilled in the tank. The holes in the box were countersunk so as to be easily located when putting the bolts through after the box had been lowered to position, the bolts being inserted in the holes in the tank after the wooden plugs had been pulled out one by one.

The box was then drawn up to the tank securely, the plug in the center hole was pulled, and the oil in the box was drained out. A 4-in. flange was placed against the tank and central with the box. Then the bolt holes were scribed, also the bore of the flange opening. The center was drilled out with a small drill, and the bolt holes were drilled. The flange was then placed after putting an ⅛-in. asbestos sheet gasket between the brass flange and the tank. The flange bolts were put in place from the inside of the tank by means of the flange opening in the tank and were drawn up tight. The flange was made of brass so as to obviate any chance of breaking when tightening. A nipple had been screwed tightly into the flange before bolting it to the tank, so as not to have any difficulty in screwing it in later, in case the flange should spring in bolting it to the tank. A valve was screwed to the nipple and then closed. The bolts were unscrewed from the box, leaving it free, and the bolt holes in the tank were tapped and plugged with patch bolts. The oil line was then put in service and has been in use ever since.

Sasco, Ariz. RALPH LEWIS.

Scale Deposited in Tray

One of several return-tubular boilers in a certain plant is fed through the blowoff line. The effect on the circulation of the water in the boiler was such that all loose scale was deposited on the front sheet over the furnace. This resulted in a badly bagged boiler on two occasions. A boiler inspector suggested the introduction of a tray, as shown in the illustration. This is put in place through the front manhole. At times, especially when boiler compound is used, this tray is full of loose scale at the end of two weeks. No loose scale is found in any other part of the boiler. The use of this tray keeps the scale from piling up on the sheet and has done away with the old hazard of a bagged boiler. J. L. BALL.



SCALE DEPOSITING TRAY IN BOILER

Amsterdam, Ohio.

Changes in Header Piping

Referring to the letter, "Changes in Header Piping," on page 327 of the Mar. 4 issue, I wish to state for the information of Mr. Wakeman that there is a large trap connected to the other end of the header by a 2-in. line. This was not shown in the previous article.

When sudden overloads come on, the unit that the 6-in. line supplies pulls over large slugs of water, and these are entirely too great in volume to be handled by a 1¼-in. line, as suggested by Mr. Wakeman, to clear the 6-in. line as it should be done. What is to prevent the steam in the boiler from circulating up through the 1¼-in. pipe to the header, in the arrangement described by Mr. Wakeman?

As for the excessive radiation surface, a good grade of covering has practically eliminated that loss.

Memphis, Tenn. J. A. Landolina.

Mechanical Equipment of Industrial Buildings

In the article on "The Mechanical Equipment of Industrial Buildings," page 244 of the Feb. 18 issue, a calculation is made showing how the steam charged to the power account can be estimated where the exhaust from the engines is used to heat the building or for other purposes.

In this calculation an allowance of 20 per cent. is made for the loss in heat units by the steam in being passed through the engine due to condensation. Although this percentage is the one commonly used in making calculations of this nature, it would appear that it is too high in view of recent observations by operating engineers and others. A horizontal high-speed engine will not convert much more than 5 per cent. of the heat supplied to it into mechanical energy. To allow 15 per cent. for condensation seems excessive in view of the comparatively small area of the cylinder, steam chest, etc.

A 100-hp. high-speed engine with a water rate of 32 lb. would, under these conditions, condense about 500 lb. of steam per hour, and this condensation would take place in a cylinder the superficial area of which is about 15 sq.ft., or at a rate of 33 lb. per sq.ft. per hour. This rate is many times higher than that obtained from uncovered steam piping, and it would therefore appear that the assumption made as to the loss in the cylinder is somewhat liberal.

It is true that there is a considerable amount of initial condensation when steam is admitted to the cylinder at the beginning of the stroke, but this condensation is largely reëvaporated before exhaust takes place, so that it does not represent a direct loss in the heating value of the steam discharged by the engine into the heating system.

In addition to this, in exhaust steam there is undoubtedly some property which makes it more effective as a heating medium than live steam of the same pressure. Just what is the cause of this is hard to explain, but it is a well-known fact among operating engineers that a building can usually be heated more effectively and with a lower pressure on the system using exhaust steam than with live steam. Using a lower pressure in the system naturally reduces the steam consumption, and in many cases it would appear that, where all the exhaust can be utilized, no steam should be charged to the power account, as the coal consumption is the same whether the engines are running or not. Indeed, some engineers claim that they actually save coal by operating their engines and that on Sundays and holidays the steam consumption of the heating system is increased on account of the machines being shut down. D. F. Grahame.

Ottawa, Ont.

Calculating Heat Loss in Water

Replying to Mr. Molloy's query relating to "Calculating Heat Loss in Water," published on page 219 of the Feb. 11 issue of *Power*, I am of the opinion that he does not get anything like steam, or 212-deg. temperature, in his feed water.

It is a fact, acknowledged by authorities, that closed heaters are seldom provided with sufficient heating surface to raise the temperature to more than 200 deg. In order to raise the temperature of 1000 lb. of water from 60 to 212 deg., the heating surface would be almost 1 sq.ft. per hp., and it is not likely that Mr. Molloy's heater has any such proportions.

In regard to the heat lost to the sewer from the heater and the heating system, we may assume that it has a temperature of 212 deg. unless thermostatic traps are used and the temperature worked down to a lower point. In a plant with which I am acquainted about 27,000 lb. of water per hour is used. The raw water is at a temperature of 44 deg., and a closed heater raises it to 144 degrees.

The steam pressure carried is 100 lb. If the boiler plant has an efficiency of 50 per cent., the coal a calorific value of 14,000 B.t.u. and the loss of steam due to leakage, condensation and oil separators equals 20 per cent. of the balance being used for heating the building and the feed water and then going to the sewer at 212 deg., which I am satisfied that it does, the loss of coal to the sewer per hour would equal

$$\frac{27,000}{7000} \times \frac{80}{100}(212 - 44) = 518 \text{ pounds.}$$

As there is enough exhaust steam going to waste in the plant in question to heat the water to 212 deg. in an open heater, it looks to me as if Mr. Molloy's closed heater is an expensive proposition.

The heat units saved per hour by an open heater over that saved by the closed heater would equal $27,000(212 - 144) = 1,836,000$. On a basis of 50 per cent. efficiency this would equal $1,836,000 \div 7000 = 262$ lb. of coal per hour. There would also be a saving of water, the quantity being calculated about as follows: As the condensation in the heater is in contact with the water until it leaves the heater, its temperature must be 212 deg. The latent heat of the exhaust steam, 966 B.t.u. per lb., is the only heat used in heating the water.

The quantity of water heated by one pound of exhaust steam would therefore be $\frac{966}{144 - 44} = 9.66$ lb. And the quantity of condensation would equal $27,000 \div 9.66 = 2800$ lb. per hour, nearly. As Mr. Molloy gives no data in connection with his plant, no figures can be given for it, but I believe the foregoing calculations will enable him to solve his own problem.

Toronto, Ont., Canada. R. McLaren.

Inquiries of General Interest

Coefficient of Expansion of Mercury—What is the coefficient of expansion of mercury per degree Fahrenheit? J. V. H.

For practical purposes the cubical expansion of mercury may be taken as 0.0001 per degree Fahrenheit. The coefficient increases with the temperature. According to determinations made by Regnault, the mean coefficient between 32 deg. F. and 212 deg. F. is 0.00010086; between 212 and 392 deg. F. it is 0.00010338; and between 392 deg. F. and 572 deg. F. it is 0.00010646.

Magnet Coils Wound with Iron Wire—Has iron wire ever been used to any great extent for winding magnet coils, and what would be the objections to its use? A. S. M.

If iron wire has been used at all for winding magnet coils its use has been very limited. On direct current, the chief objections are the high resistance of the conductors, which results in a large and inefficient coil; the winding being made of magnetic material (iron) permits excessive flux leakage, which decreases the pull of the magnet. In alternating-current work there is the additional objection of the hysteresis and eddy-current losses in the winding, which also decrease the efficiency of the magnet.

Repeated Breakage of Gas-Engine Crankshaft—We are having considerable trouble from repeated breakage of the crankshaft of an 80-hp. producer-gas engine. May not the trouble come from improper adjustment or poor lubrication of the bearings and crank boxes? S. S.

Repeated breakages are more likely due to shocks from preignition and impacts to which internal-combustion engines are subjected. A crankshaft usually breaks after the material has become crystallized, and when a break has occurred, it may be taken for granted that more or less crystallization has taken place throughout the whole crankshaft material. The original structure can be nearly recovered by heat treatment, and the whole crankshaft should be so treated occasionally—at least whenever any part is repaired by rewelding.

Dull Black Finish for Brasswork—What treatment is given brasswork to impart a dull black finish? A. W. B.

Make a concentrated solution of copper in nitric acid and add an equal quantity of water. The surfaces to be blackened should be bright and washed clean of grease. If the article is large, swab the surfaces with the diluted copper solution; if small, immerse it in the solution. After draining or shaking off the solution, heat the article until the copper salt is converted to a black oxide. The heating may be done over a clean coal fire, but better results will be obtained by heating the articles in a closed muffle furnace, so as to obtain uniformity of heating and coloring. For some kinds of work more uniform results may be obtained by using a weaker solution, as one part of the concentrated solution to two parts of water.

Referring Vacuum-Gage Reading to 30-In. Barometer—What is the rule for converting vacuum-gage readings to inches of vacuum referred to a 30-in. barometer? For example, when the barometer stands at 30.8 in. and the vacuum-gage reading is 26 in., neglecting differences due to variations of temperature, what would be the vacuum referred to a 30-in. barometer? S. R.

When the barometric pressure of the atmosphere is 30.8 in., a vacuum gage reading of 26 in. of mercury column would indicate an absolute condenser pressure of $30.8 - 26 = 4.8$ in. of mercury, and for 30-in. barometer, the same absolute pressure would be equivalent to $30 - 4.8 = 25.2$ in. vacuum. Hence, to refer vacuum-gage readings to a 30-in. barometer, neglecting allowance for difference of temperature, subtract the actual reading in inches from the actual height of barometer and subtract this difference from 30; or, what is the same thing, add 30 to the reading and subtract the actual height of barometer.

Coal Chargeable to Use of Closed Heater—How much coal should be charged per 100 cu.ft. of water, heated from 60 to 200 deg. F. in a closed exhaust-steam heater? W. S. S.

The amount of coal chargeable will vary in different cases. The service should be charged with the cost of any increase of average back pressure on the engines; or on the other hand, if the heater acts like a condenser of the exhaust and reduces the back pressure, then the service should be credited with the improvement of economy resulting from reduction of the average engine back pressure. The increase or decrease of average back pressure on the engine, due to use of the heater, should be determined from indicator diagrams of the engine taken with the average load before and after the heater is installed. Then multiplying the pounds of coal originally required per pound m.e.p. per hour by the variation in back pressure will give the quantity of coal to be debited or credited to use of the heater.

Electromagnet Construction—Why is it that some electromagnets will operate on either direct current or alternating current, and others will operate on only one class of circuit? What is the difference in construction in a direct-current and an alternating-current electromagnet? W. A. S.

In a direct-current electromagnet the magnetic path is made of solid iron in some form or other. The coil is wound with wire of sufficient resistance to keep the current down to a safe operating value. In the alternating-current electromagnet, owing to the eddy currents that would be induced in the magnetic path if made of solid iron, the magnetic path must be laminated; that is, built up of thin sheets. The eddy currents induced in the magnetic circuit, if made of solid iron, would cause excessive heating. To prevent the alternating-current flux from causing the magnet to chatter, a shading coil is generally used. This coil consists of a loop of copper around one of the poles of the magnet.

In any alternating-current coil the current is limited by two factors—the resistance of the coil and the induced electromotive force. Consequently, a coil used on an alternating-current magnet, of the same lifting power as a direct-current magnet, will have considerably lower resistance than for the latter type.

Small magnets, such as used for ringing bells, can be constructed so that they will work on both direct and alternating current. This is because an efficient magnet is not required and the magnet is in service only for very short periods. However, it will be found that the magnet will be considerably stronger when used on a direct-current circuit than when on an alternating-current circuit of the same voltage. With large, well-designed magnet coils it will be found that if a direct-current magnet is connected to an alternating-current circuit of the same voltage that the coil is designed for, practically no current will flow through the coil owing to its high inductance. On the other hand, if an alternating-current magnet is connected on a direct-current circuit of its rated voltage, the current taken by the coil will be excessive and the coil will in a very short time reach an excessive temperature.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Construction and Operating Costs of Water Power in Maine

By H. K. Barrows[*] and Edward F. Miller[†]

An interesting and able presentation of the conditions that influence the cost of power, whether it be steam or water. The article is part of a report by these engineers to the Public Utilities Commission of Maine, which deals with a special water-power investigation.

THE cost of power is fundamentally affected by the type of prime mover, in the case of units of about 500 hp. particularly. The manner of use of the plant, however, is an important factor in the cost of power, whether the source be water or steam. For illustration, a plant in use but ten hours of the day is spending a large part of its time in idleness, and the item of fixed charges for such ten-hour power would obviously be relatively greater than if the plant were in practically continuous use. The variation in load to which the plant is subjected is another important factor affecting the cost of power, and here again a plant which is supplying a power demand varying between wide limits is obviously at a disadvantage in respect to the cost of power produced.

Load Factor—Technically, the relation between average and maximum load at a plant is called the load factor, with some further reservation as to the time to which this applies. So we speak of the daily, monthly or yearly load factor usually with reference to the time during which the plant is running. The amount of machinery required is obviously inversely proportional to the load factor, and a high load factor means that a machine is running with little variation in output and therefore with greater economy than if a low load factor prevailed. For central stations load factors as low as 30 to 40 per cent. are not uncommon, while with industrial plants load factors as high as 80 or even 90 per cent. are sometimes reached. The raising of the load factor in the central station is one of the continual aims of efficient operation, meaning, as it does, a building up of the load curve in those parts of the day when the ordinary use of power is at a minimum. To bring this about means a judicious blending of customers with varied power demands as regards time of day. It is especially desirable to obtain, if possible, power users for the night period, from, say, 8 p.m. to 6 a.m. This means including considerable 24-hour power, or more particularly power uses such as for pulp and paper manufacture, electrochemical work, pumping, etc., which can be carried on during the night hours and in part limited to these hours.

Capacity Factor—Capacity factor is a term which takes account of not only load factor but the proportion of the time during which the plant is running. It is defined as the ratio between the total output of the plant as run at its rated capacity, 24 hours per day, the entire year, and the actual output of the plant in the same period. Obviously, for a plant running 24 hours per day, 365 days per year, the load factor and capacity factor are the same figure, provided that the rated capacity of the plant is the same as the maximum load demand or, in other words, that no spare power units are included. The load factor and capacity factor are always less than unity.

Diversity Factor—Diversity factor applies particularly to the use of power and takes account of the fact that all customers do not simultaneously require current enough to run their connected loads to full capacity, but have a diversity of demand; hence, the number of kilowatts of station capacity is always less than the number of kilowatts of connected load. If there were no losses of current in the transmission lines, the total true diversity factor would be the quotient obtained by dividing the total connected load by the station peak load. The actual diversity factor would be somewhat modified by losses of power in the transmission lines.

Comparative Utility of Water and Steam Power—Fundamentally, the hydraulic turbine has a great advantage—with an efficiency of about eight times that of the steam engine or steam turbine, and lower operating costs. It might seem at first thought, therefore, that water power would always be cheaper and more desirable. The usual high first cost of a water-power plant, almost always greater than for a steam plant, means greater fixed charges. Moreover, for inland water power to compete with steam plants adjacent to tidewater a considerable additional annual cost for transmission lines must be charged to the water-power costs in comparing them with steam electric power.

Cost of Steam Power—The reciprocating steam engine is perhaps the most widely distributed prime mover in use, although, as previously noted, its field of use has in the last few years been considerably encroached upon by the steam turbine. For smaller units—that is, below 1000 hp.—the reciprocating engine is likely, all things considered, to be superior in economy to the steam turbine. For the particular scope of this discussion, however, with special reference to the relative economy of steam and water power, usually dealing with units of 1000 hp. or more, the comparison would be practically with reference to steam-turbine driven electric plants.

First Cost of Steam Plants—The cost of steam electric stations is usually expressed in kilowatts, or sometimes in horsepower, with reference to the rated generator capacity; that is, the full output of the generators at the switchboard. Under normal conditions, the cost with units of 1000 kw. and over, the total cost per kilowatt is between $80 and $90. The cost with small units may exceed this figure quite materially, while with very large units, for illustration, 25,000 kw., the cost per kilowatt is usually lower. For purposes of general comparison, $80 to $90 per kilowatt as the total cost of steam plant is a reasonable figure. This total cost per kilowatt of, say, $85 is made up normally of about $40 for the steam plant, $30 for the electric plant and $15 for power house, boiler house, etc.

In the Table I data are given of reported costs of steam and electric and total plant cost (not including power and boiler house) for selected good-sized central stations as given in the annual reports of the Massachusetts Gas and Electric Commission, for the years 1914-17 inclusive. Data for the individual stations vary considerably. The average results, however, appear to be fairly constant.

TABLE I. COST OF STEAM-ELECTRIC PLANTS FOR SELECTED MASSACHUSETTS CENTRAL STATIONS, 1914-17

	Cost per Kilowatt		
Year	Steam Plant	Electric Plant	Total
1914	$40 70	$28 40	$60.10
1915	42.50	28.00	70.50
1916	36.00	24.60	60.60
1917	40.00	30.00	70.00
Average	$39 80	$27 80	$67 60

With cost of power and boiler houses included, of $15 per kw., the average cost of these plants would be $83 per kw.

Cost of Power from Steam Electric Plants—The cost of power is made up in general of two items, that of the fixed charges usually taken to include interest, depreciation, taxes and insurance, and the operating charges which, for a steam station, should include fuel, wages, repairs and miscellaneous items, such as the use of oil, waste, etc.

Interest is taken usually at 5 to 6 per cent., taxes and insurance at 1½ to 2 per cent., and depreciation at 4 to 5 per cent., all with reference to construction cost. Obviously, the depreciation of the different items of a steam plant will show large variation. Depreciation in the sense as ordinarily used is a function of the life of the plant, and as the different portions of the plant may have a life varying from 10 to 30 years, or even more, the depreciation of particular items may vary from 10 per cent. per year to as low as 2 per cent., a fair average for the whole plant being 4 to 5 per cent. The total annual fixed charges for a steam plant are, therefore, about 12 per cent. of its first cost.

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Operating Costs — The important operating costs are those of fuel and labor. Coal consumption varies within quite wide limits from 5 to 6 lb. per i.hp.-hr. for small units to as low as 1.5 lb. per i.hp.-hr. for very efficient reciprocating steam engines. For steam turbine electric units of 1000 kw. or over, the coal consumption will be about 2 lb. per i.hp.-hr., or about 3 lb. per kw.-hr. at the switchboard. Labor costs, including engineers, firemen and helpers, are also a considerable item in the cost of power by steam. In the Table II data are given of operating costs and amount of fuel used for the several central station plants in Massachusetts for the years 1914-17, inclusive. In all cases in this report the ton of 2000 lb. is used:

TABLE II. OPERATING COSTS, ETC., AT STEAM ELECTRIC PLANTS FOR SELECTED MASSACHUSETTS CENTRAL STATIONS, 1914-17

Cost of Coal per Ton of 2000 Llb.	Lb. of Coal per Kw Made	Cost per Kw., Cents			
		Coal	Wages	Miscellaneous	Total
$4.00	2 75	0.55	0 19	0 14	0 88
5.00		0 69			1 02
6.00		0 83			1 16
10 00		1.37			1 70

It will be noticed that about 1.75 lb. of coal was required per kilowatt-hour at the switchboard, which would correspond to about 1.8 lb. per i.hp. At the pre-war cost of coal, the total operating cost per kilowatt-hour was about 0.88c., of which about 62 per cent. represented fuel cost, 22 per cent. wages, and the remainder miscellaneous costs. No data are available as to the average load factors at these plants, but it is probably about 40 to 50 per cent. With coal at $10 per ton, a total operating cost of about 1.7c. per kw.-hr. would result, about 81 per cent. of this representing the cost of coal. The future cost of coal is somewhat problematical.

Total Cost of Steam Power—The previous table gives estimated central-station operating costs with different assumed costs of coal. The total cost per kilowatt-hour of power would include the fixed charges on the cost of plant.

Assuming a total plant cost of $85 per kw., annual fixed charges at 12 per cent. would be $10.20 per kw., or 0.12c. per kw.-hr. with a 100 per cent. load factor and no allowance for spare units or excess capacity. It is to be noted that with no excess capacity or spare units, the item of fixed charges would practically vary inversely with the load factor. The actual load factor for these plants was probably from 40 to 50 per cent., so that the actual fixed charges would be perhaps about 0.40c., making some allowance for probable excess capacity at these plants.

The total cost of power at the switchboard at these stations would, therefore, be as follows for various different costs of coal:

Cost of Coal per Ton	Total Cost per Kw.-Hr.
$4 00	1.28c.
5 00	1 42c
6 00	1 56c.
10.00	2 10c.

The cost of coal at various points in the State of Maine under normal and war conditions are as follows:

Location	Normal Cost	Max. War Cost
Augusta	$4 00	$12 50
Bangor	4.00	12 50
Lewiston	4.25	12 00
Portland	3.50	10 90
Average	3 94	11 98

Based on the results obtained at these central stations in Massachusetts, from which the figures formerly given were taken where coal averages $4 per ton, it will be noticed that the total cost of manufacture, including fixed charges, has been approximately 1.3c. per kw.-hr., which also represents fairly well the cost of steam power at ordinary steam electric stations in the State of Maine under pre-war conditions.

The cost of steam electric power at isolated plants has been covered in considerable detail for different conditions of operation in a paper prepared by William F. Uhl, published in the *Journal of the American Society of Mechanical Engineers* for November, 1918. In the Table III are given costs of power for a 1000-kw. steam plant based on data in this article, assuming a cost of $85 per kw. for the total cost of steam electric plant with the various costs of coal.

TABLE III. COST OF POWER IN CENTS PER KW.-HR. AND DOLLARS PER HP.-YEAR FOR 1000-KW. PLANT OPERATING 24 HOURS PER DAY, 365 DAYS PER YEAR

Cost of Coal per Ton of 2000 Lb.	Load Factor, Per Cent.			
	100	80	50	30
$4 00	0 79c. $51 50	0 90c. $58 90	1.25c. $82.40	1 58c. $104
5 00	0 91 59 50	1 02 66 70	1 40 91 60	1 86 122
6 00	1 03 67 20	1 14 74 60	1 54 101	2 03 133
10 00	1 49 97 50	1 64 197	2 13 140	2 67 175

For plants of larger capacity these costs would be slightly less. The agreement in cost, however, with that previously given for Massachusetts central stations (where the load factor is probably from 40 to 50 per cent.) is fairly good as will be noted.

Load factors obtained by various power companies in the State of Maine are as follows: Androscoggin Electric Co., 42 to 60 per cent.; Bangor Railway and Electric Co., 85 per cent.; Gould Electric Co., 85 per cent.; Rockland, Thomaston & Camden Street Railway, 60 per cent.; Central Maine Power Co., 55 per cent.; Cumberland County Light and Power Co., 50 per cent.; Rumford Falls Power Co., 95 per cent.

Assuming that future load factors may be built up to approximately 60 per cent. for miscellaneous power and lighting use, it appears that the cost of steam power for such service will be about 1.1c. per kw.-hr. at the switchboard based upon pre-war costs of coal as well as wages.

With coal at $5 per ton, this cost would be increased perhaps nearly 0.15c. per kw.-hr. It seems reasonable to conclude that a cost of 1¼c. per kw.-hr. at the switchboard is likely to be reached for the cost of power from steam-electric central power stations in Maine; that is, for stations in general adjacent to or near the coast.

The estimates made of the cost of constructing plants at undeveloped water-power sites in Maine show an average cost for the four principal rivers of $99 per horsepower. The average cost of all plants both developed and undeveloped is $107 per horsepower. The cost of individual plants will vary from $60 per horsepower as a minimum up to $250 or more where sites are not especially good or where conditions of development are difficult.

To indicate the general extent to which load factor affects the first cost of plant, the Table IV has been prepared.

TABLE IV. EFFECT OF LOAD FACTOR ON COST OF HYDRO-ELECTRIC PLANTS

Cost of Plant to Deliver 1 Hp. on Wheel Shaft with Different Load Factors						Per Cent. Increase in Cost Over That for 100 Per Cent. Load Factor		
100 Per Cent. Load Factor			80 Per Cent.	50 Per Cent.	30 Per Cent.	Load Factor, Per Cent.		
Equipment and Power House etc.	Other Costs	Total Cost	Total Cost	Total Cost	Total Cost	80 Per Cent.	50 Per Cent.	30 Per Cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$40	$210	$250	$260	$290	$343	4 0	16 0	37 3
40	160	200	210	240	293	5 0	20 0	46 5
25	175	200	206	225	258	3 1	12 5	29.1
30	70	100	108	130	170	8 0	30 0	70 0
25	35	60	66	85	118	10 4	41.6	97 2
20	40	60	65	80	107	8 3	33 3	77 7

In a general way a power development which costs $200 to $250 per horsepower is likely to be on a large stream tending to a moderate or low-head development, under which conditions the cost of equipment and power house is likely to be at a maximum. For this case, therefore, the range in cost of equipment and power house has been taken from $20 to $40 per wheel horsepower. Similarly, a low cost of development at $60 per horsepower is likely to be a high-head development, with usually a moderate amount of water. This tends toward lower cost of equipment and power house, and the range here has been assumed from $20 to $25 per horsepower on the basis of 100 per cent. load factor. The relative costs of such plants with varying load factors are given in columns 4 to 6 inclusive, of this table, and in columns 7 to 9 inclusive, the per cent. increase in cost over that for a load factor of 100 per cent. It will be noted that for the upper limit in cost of development, $250 per horsepower, the per cent. increase in total cost due to the load factor being other than 100 per cent. varies from about 4 per cent. with an 80 per cent. load factor to nearly 40 per cent. load factor. With the low-cost plant assumed at $60 per horsepower, this increase in cost is about 10 per cent. for an 80 per cent. load factor and 80 to 100 per cent. for a 30 per cent. load factor.

With a load factor of from 50 to 60 per cent., which may be expected for conditions in Maine, the cost of plant may be increased from about 15 to 40 per cent. over that for a load factor of 100 per cent.

Cost of Water Rights—On the basis of development upon a 60 per cent. flow basis and 100 per cent. load factor used in estimating the cost of development for various rivers in Maine, an amount varying from $10 to $40 per horsepower represents the approximate range in cost of water rights, including land.

Cost of Power from Hydro-Electric Plants — Fixed charges on the cost of water-power developments, or the basis for annual cost of power, constitute approximately 10 per cent. of the construction cost, the variation being about as follows:

	Per Cent.
Interest	5-6
Depreciation	2-3
Taxes and insurance	1-2
Total	8-11

Operating charges, the principal items of which are wages and repairs, are low. These will naturally vary materially with the capacity of the station and with load factor. They will usually be 0.1c. or less per kilowatt-hour of power delivered at the switchboard for good-sized hydro-electric plant with a load factor approaching 50 per cent.

Assuming annual fixed charges at 10 per cent., their cost per kilowatt-hour for 24-hour 365-day power is given in the Table V, using the range in first cost and load factors as given in the previous table:

TABLE V. FIXED CHARGES FOR HYDRO-ELECTRIC PLANTS WITH VARYING COST OF PLANT AND LOAD FACTOR

Cost of Plant per Horsepower		Fixed Charges in Cents per Kw.-Hr. of Output at Switchboard			
		Load Factor, Per Cent.			
Total Cost	Cost of Equipment and Power House	100	80	50	30
$250	$40	0 41	0 43	0 48	0 56
200	40	0 33	0 35	0 40	0 48
200	25	0 33	0 34	0 37	0 43
100	30	0 16	0 18	0 21	0 28
60	25	0 10	0 11	0 14	0 19
60	20	0 10	0 11	0 13	0 18

The hydro-electric plants on the rivers considered would not deliver their full output for 40 per cent. of the year. The 95 per cent. or primary output is from 70 to 80 per cent. of the full output on these rivers with storage regulation, so that only about 5 per cent. less than the full output would result for the average year. Making this slight deduction and keeping in mind 50 to 60 per cent. load factor, as was assumed for future steam plants, it is evident that hydro-electric power can be delivered at the switchboard for from about 0.25c. to 0.6c. per kilowatt-hour for the range of cost of developments found on the rivers in Maine.

An economic study of transmission lines in Maine indicates the superiority of steel tower lines.

TABLE VI. ESTIMATED COST OF TRANSMISSION LINES

Distance, Miles	Capacity of Line, Kw.	Line Voltage	Number of Tower Lines	Number of Wires per Tower	Total Cost per Mile
25	5,000	66,000	1	6	$3,500
25	10,000	66,000	1	6	5,000
25	20,000	66,000	1	6	7,000
50	10,000	66,000	1	6	5,000
50	25,000	66,000	2	6	10,000
50	50,000	100,000	2	6	14,000
75	50,000	100,000	2	6	14,000
75	100,000	150,000	2	6	20,000
100	100,000	150,000	2	6	20,000

Cost of Transmitting Power—In Table VII is given the cost per kilowatt transmitted and the annual cost per kilowatt-hour for the different lines, assumed by Professor Hudson. The table shows that power transmission at a cost of about 0.10c. per kilowatt-hour or less is readily obtainable.

Cost of Storage Reservoirs—The average cost per million cubic feet of storage capacity is about $33. Storage on the Presumpscot River has already been developed and the extremely low cost of $10.79 per million cubic feet of capacity has been made possible by the great natural storage facilities of Sebago Lake.

Cost of Increased Primary Power Due to Storage — At developed sites on the six large rivers of Maine, this increase in primary power would be about 79,000 hp., costing about $34 per horsepower, or an annual cost, including operation, of $3.42 per horsepower. If all suggested power developments were made, a total increase in primary power of 168,000 hp. would result, at a total cost of $16 per horsepower, or an annual cost, including operation, of $1.60 per horsepower. To guarantee primary power with steam auxiliary means for annual fixed charges alone at least $7.50 per horsepower of plant, or more than double the average annual cost of storage, including its operation.

TABLE VII. ESTIMATED COST OF POWER TRANSMISSION

Length of Line, Miles	Capacity of Line, Kw.	Total Capital Cost of Line	Capital Cost per Kw Transmitted (50 per Cent. Load Factor and 5 per Cent Losses)	Cost per Kw.-Hr (With Annual Cost 25 per Cent of First Cost)
25	5,000	$87,500	37	0 10
25	10,000	125,000	26	0 08
25	20,000	175,000	18	0 05
50	10,000	250,000	53	0 15
50	25,000	500,000	42	0 12
50	50,000	700,000	29	0 08
75	50,000	1,050,000	44	0 13
75	100,000	1,590,000	32	0 09
100	100,000	2,000,000	42	0 12

There is one additional factor not yet discussed, which would in general tend to increase the relative cost of hydro-electric power as compared with steam; that is, the including in annual costs of a fair return upon investment, in addition to that assumed of 6 per cent. In other words, instead of assuming 10 per cent, and 12 per cent., respectively, for annual fixed charges for water and steam plants, these should, to take allowance of investment considerations, be, say, 17 per cent. and 18 per cent. respectively, allowing 1 per cent. greater in this added factor for water power, on account of the greater risks involved.

When Fellers Needs Friends : : : By BRIGGS

Refrigerating Plant Efficiency*

BY VICTOR J. AZBE†

The paper deals with the conditions prevailing in the majority of refrigerating plants and makes suggestions in regard to increasing the efficiency of their operation. The variations of the load factor should be considered in selecting the size of boiler. High boiler efficiency depends more upon design and intelligent operation than upon the quality of fuel used. The author condemns the practice of using a Corliss noncondensing engine for the prime mover on account of its large steam consumption when operated at fractional loads. He recommends the uniflow steam engine and the Diesel oil engine.

DURING the last two years the cost of fuel per ton of ice has doubled or trebled, and many plants are now paying from $1.50 to $2 per ton of ice for fuel alone, and the situation is becoming still more acute because of the shortage of labor, which is rapidly growing serious.

There are far more plants making on the average, per year, 1.5 to 2.5 tons of ice per ton of fuel than plants making 5 tons, having simple noncondensing plants in mind.

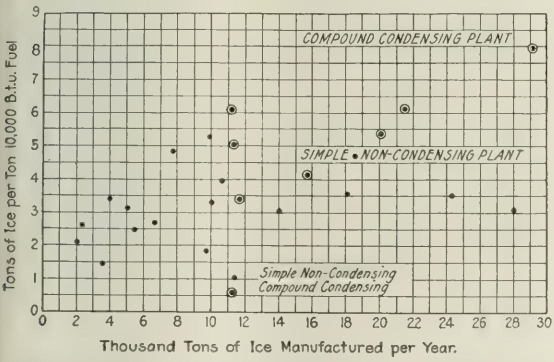

FIG. 1. YEARLY OUTPUT AND RATIO OF TONS OF ICE PER TON OF COAL

Fig. 1 is submitted as an illustration of the performance of a number of plants taken at random, showing both their yearly output and the ratio of tons of ice made per ton of coal. For example, the plant of least capacity is one of 2000 tons per year and two tons of ice per ton of coal.

In this paper the writer will express himself frequently in terms of tons of ice per ton of 10,000 B.t.u. fuel, an expression that tends to equalize the value of the various fuels (semi-bituminous, bituminous, lignite, oil, etc.), since by a simple recalculation it places them on a common basis.

With waters that have a tendency to prime, it is often the practice to underload the boilers so as to prevent priming. In a certain plant having Stirling boilers and using water containing 80 grains of chlorides per gallon, serious trouble was experienced with priming until the steam connection was changed to the rear drum, after which it was possible to operate the boilers with water having a large amount of salt without any priming developing. In the same plant scale caused by calcium sulphate was overcome by adding sodium hydroxide to sodium carbonate and lime.

As the load factor of most refrigerating plants varies greatly, the boiler installation should be such as to give flexibility of operation. In small plants arrangements should be made to reduce the grate surface during the winter periods; each boiler must be equipped with a draft gage, and the draft should be maintained at the minimum and varied with the load.

With load factors as low as 35 per cent. and a 15 per cent. fixed and operating expense, a yearly saving of 30 per cent. of economizer investment will be made, based upon fuel at $2.50 per ton of 10,000 B.t.u. and normal economizer prices. At the present economizer prices are, of course, abnormal, and so is also the cost of fuel.

The prime mover most generally used in refrigerating plants is the Corliss noncondensing steam engine. Next in order are the compound Corliss, electric motor, oil engine, and uniflow steam engine. If this order were reversed, however, enormous sums of money would be saved to ice manufacturers, for the following reasons:

In selecting the prime mover for an ice plant, the two most important items to consider are efficiency at rated load and efficiency at half load. While the average Corliss noncondensing engine consumes 20 per cent. more steam at half load than at full load, the uniflow engine uses only about 8 per cent. more. This is of great importance because of the great variations of load factor. Many engines can be found operating at one-eighth cutoff. This is the reason, also, why a steam cylinder should be adapted to the back pressure at which the compressor operates. It is most unwise to have a steam cylinder large enough for economical cutoff at 25 lb. suction pressure when the pressure to be maintained is 15 lb. or less.

TABLE I. DIESEL POWER-PLANT PERFORMANCE

	Total	Per Net Kw.-Hr
Wages paid	$4,545 10	$0.00405
Fuel-oil consumption	3,416.49	0.00305
Lubricating oil	466.86	0.00042
Repairs and supplies bought	1,116.50	0.00100
Repairs and supplies, home work	1,367.49	0 00122
	$10,912.44	$0.00974

MONTHLY RESULTS

Month	Total Power Generated, Kw.-Hr.	Total Power for Auxiliaries, Kw.-Hr.	Net Power Generated, Kw.-Hr.	Fuel Oil Consumed, Gal.	Cost of Fuel Oil per, Gal., Cents	Gal. of Fuel Oil per 100 net Kw.-Hr.
April	65,770	7,176	58,594	5,141	3.63	8.774
May	95,270	10,712	84,558	8,142	3.63	9.629
June	119,340	13,785	105,555	10,671	3 61	10 109
July	132,150	14,482	117,668	10,843	2 9	9 215
August	131,540	16,275	115,265	12,593	2 65	10 925
September	114,840	12,973	101,857	10,125	2 33	9 94
October	114,120	12,567	101,540	9,431	2 31	9 288
November	110,160	12,737	97,423	9,459	2 56	9 709
December	113,330	12,159	101,071	9,660	3 00	9 558
January	86,640	11,213	75,427	7,220	3 13	9 572
February	84,490	9,489	74,991	6,993	4 5	9 325
March	128,570	14,413	114,157	11,175	4 5	9 789
April	100,350	11,656	88,694	8,766	7 0	9 883
May	108,950	12,871	96,079	9,232	6 15	9 605
June	176,000	19,100	156,900	15,488	6 15	9 871
July	168,490	17,333	151,167	14,946	4 25	9.89
August	150,890	18,652	132,238	13,569	4 25	10.261
September	90,450	11,029	79,421	8,052	4 5	10 138
October	61,700	8,201	53,499	5,591	4 87	10 45
November	42,540	5,867	36,673	4,076	4 87	11.114

Fig. 2 shows the results to be expected from various types of installations. The allowance made for auxiliaries ranges from one-half to one horsepower per ton of ice, depending upon conditions. The condenser pressure was taken at 185 lb. gage, and it was assumed that at the suction pressure given the machine would operate at about full load.

In small plants preference should ordinarily be given to the use of superheated steam, since as high an economy may be obtained from a uniflow noncondensing engine operated with superheated steam as from a compound Corliss condensing engine using saturated steam, and the former equipment is a great deal simpler and requires less auxiliary power. Furthermore, the steam-consumption curve is flat and the efficiency of the plant will be maintained during the winter time.

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*Presented at the annual meeting, December, 1918, of the American Society of Mechanical Engineers, New York.

†Consulting Engineer, St. Louis, Mo.

Superheaters can be installed with facility even in existing installations, and since the gain is greater with simple noncondensing engines, uneconomical ice plants will derive great benefit.

In the majority of ice plants the initial steam pressure in the steam cylinder is from 70 to 90 lb. Even in plants having high-pressure boilers the benefit to be derived from high-pressure steam is not usually taken advantage of. Tests show an economy increase of 7.5 per cent. by raising the pressure from 75 to 100 lb., and of 4 per cent. by raising it from 100 to 125 lb.

In order to gain in economy, a simple engine is often made to operate as a condensing engine. As a result the temperature difference in the cylinder is increased and the cutoff is shortened, which increases the wall area at cutoff as compared to volume. This greatly increases cylinder condensation, which is directly proportional to the temperature difference and the area exposed. It therefore seldom pays to operate such a machine at more than 20 in. of vacuum, and if the plant is to be changed over to condensing operation, it is best to replace the simple Corliss by compound cylinders or by a uniflow engine and leave the rest of the machine intact.

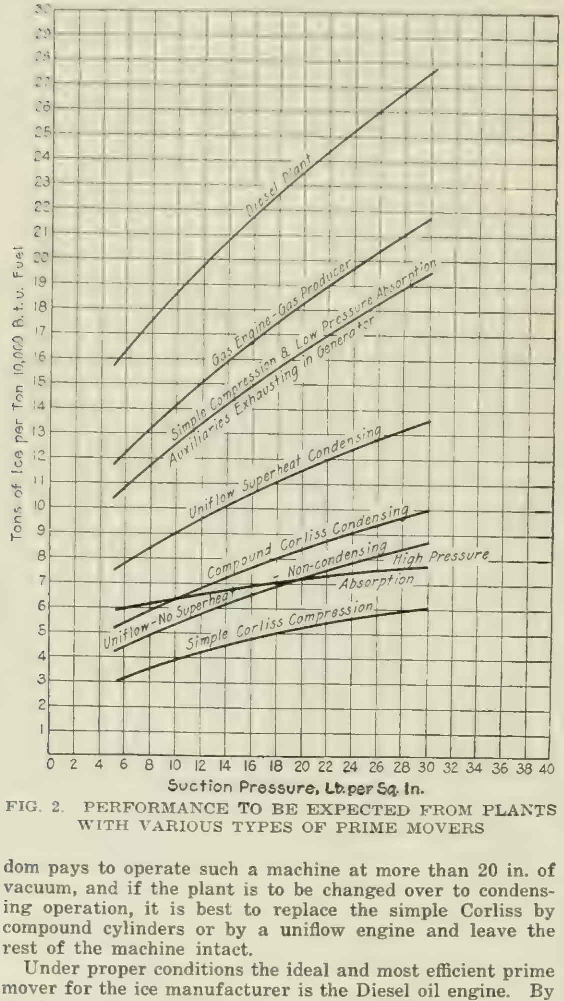


FIG. 2. PERFORMANCE TO BE EXPECTED FROM PLANTS WITH VARIOUS TYPES OF PRIME MOVERS

Under proper conditions the ideal and most efficient prime mover for the ice manufacturer is the Diesel oil engine. By "under proper conditions" is meant conditions of oil supply and cost, and kind of operating force to be employed. It cannot be overemphasized that with the Diesel engine a high-grade engine-room force must be maintained, especially during the overhaul period. If the men in charge are intelligent, the Diesel engine is a dependable unit. There is a plant in California that produces a ton of ice for 5 gal. of fuel oil, and this not under the best conditions. There are oil-engine installations on record, not necessarily Diesel engines, that have given a ton of ice for less than 10c. fuel cost, with oil at 2c. a gallon.

Table I gives the average results obtained with Diese engines over a long period. The net work produced wa 1,119,801 kw.-hr. The auxiliary power represented th power required for injection, in the air compressor, and i the water-jacket circulating pumps. The load factor havin been highly variable, the results are not quite so good a they otherwise would have been, consequently the figure may be taken as being rather conservative and dependable

In many localities electric power can be obtained quit cheaply, and when this is the case electric drive is to b favored. The main advantage of an electric installation i that high efficiency can be obtained through the whole load-factor range and that economy increases as the load facto drops, contrary to the condition in ice plants.

Induction motors are not very well adapted for ice-plant work because of the high speeds required for high efficiencies. Synchronous motors, on the other hand, have characteristics that make them ideal, even for direct connectio to refrigerating machines. Their efficiency curve is quit flat, and their efficiency is rather high at part loads.

The standard requirement for auxiliary power per ton of ice produced should be 0.5 hp., and every effort should b made to keep down to this figure. In some plants the auxiliary power far exceeds 1 hp. per ton of ice.

For driving auxiliaries, electric current from generator driven by uniflow engines is to be preferred in the majority of installations, and the various units must be selected with a view to obtaining a flat efficiency curve between half and full loads; all motors on the larger units should have variable speed control.

WET VERSUS DRY COMPRESSION

Theoretically, dry compression is inferior to wet, both in regard to refrigeration produced per pound of ammonia circulated and the work required for compression. The difference in economy ranges between 6 and 10 per cent., being greater with low suction pressures and high condenser pressures. Practically, however, dry compression is the more economical; that is, it is capable of producing a greater amount of refrigeration per horsepower expended. The reason for this discrepancy is that when wet gas is admitted into the cylinder the liquid is not suspended, but accumulates at the bottom of the cylinder. There it evaporates so slowly during the compression stroke that the evaporation continues after the discharge valve opens, and often even after it again closes when the piston is upon the return stroke, thus causing a certain amount of reexpansion loss which tends to reduce compressor capacity. Any liquid that evaporates after the discharge valve opens is wasted.

That there is no benefit in wet compression, as ordinarily practiced, is proved by the compression curve and its relation to the adiabatic and isothermal curves when the machine is operated wet, even to such an extent that the discharge gas leaving the compressor is saturated. In such cases the compression curve will only slightly approach the isothermal, which proves that most of the cooling of the gas by evaporation of the liquid is done after the compression valve opens and thus no benefit accrues from that time on.

To prove that the gas and the liquid do not mix and that the latter passes to the compressor in streamlike form, the following evidence is submitted:

Case 1. Two compressors of equal capacity and like design were operated upon two freezing tanks from which a single suction line led to a point midway between the two compressors. There it divided into two branches of equal size, one to each compressor. By faulty workmanship the line leading to one of the compressors was slightly lower than the one leading to the other, which caused the first machine to run with a cold discharge, while the other was very hot. This proved that all the liquid flowed by gravity into the first machine, the other receiving saturated gas only.

Case 2. In a vertical compressor having one discharge valve at the top and one at the bottom, it will be found, in wet compression, that the lower valve is cold while the upper one is very hot. This shows that the gas traveling to the lower valve in contact with the liquid will remain cold, while the gas in the upper valve becomes superheated. So long as theory indicates an advantage in wet compression, it would seem that further studies and experiments regarding its successful application are justified. Could not some method be devised to atomize the liquid before it reaches the compressing cylinder, or to inject it in the form of a spray during the compression stroke? In any event, precautions must be taken not to introduce liquid into the cylinder in an undivided state, otherwise dangerous accidents are likely to follow.

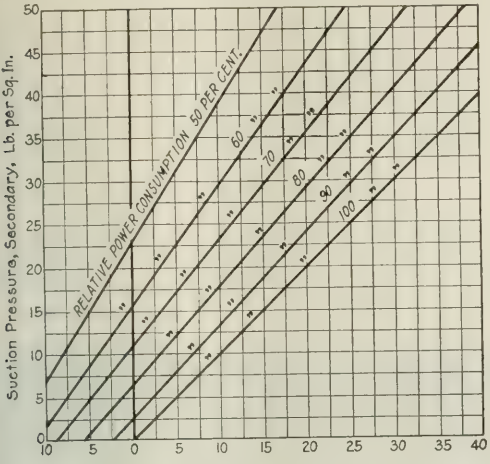


FIG. 3. INFLUENCE OF MULTIPLE EFFECT UPON COMPRESSOR POWER CONSUMPTION

Wet compression is not only beneficial upon thermodynamic principles, but possesses a number of other advantages. By its use the temperature difference in the cylinder is reduced by practically two-thirds, which greatly lowers the cylinder superheat and consequently should increase the volumetric efficiency of the machine. Further, with wet compression far less oil is required for lubrication and the oil does not vaporize and thus is easily kept out of the condensing and evaporating coils. Wet compression represents also a saving in ammonia and, in addition, permits a somewhat lower condenser pressure.

Ammonia Evaporating Systems

With expansion coils in ice tanks and cold-storage rooms a high heat transmission is very desirable, and it can be obtained inside of the pipes either by flooding them or by using a high gas velocity. The objection to high gas velocity in this connection is pressure drop, which for thermodynamic reasons is rather more important on the evaporating side than on the condensing side. For this reason the length of the evaporating coil should be limited so that the velocity will never exceed the average figure of 500 ft. per min. Some tank coils are 1500 ft. long and their rather high velocity causes a great pressure drop. For long tanks 2-in. pipe is to be preferred, since the relative surface of 1¼-in. and 2-in. pipe is in the ratio of 1 to 1.5, while the sectional area is in the ratio of 1 to 2.2. Coils should be short so that they are thoroughly effective, and even flooded coils should be as short as possible.

As to the size of suction lines leading to the machines, efforts should be made to have them below 100 ft. in length and with the least number of elbows. For greater lengths the size should be governed by permissible gas velocity, friction and radiation loss. The main considerations are the cost of fuel and the cost of installation.

In a well-designed and efficiently operated ice plant the water to be used for ice making is cooled down to within a few degrees of the coldest circulating water, or ordinarily to a temperature of 70 or 80 deg. F. This water then passes into the forecooler to be precooled by ammonia. The heat absorbed by the forecooler can be anywhere up to 30 per cent. of the total heat to be extracted in making ice, and the water will be cooled down to about 40 deg. F. There are two methods of forecooler refrigeration: By feeding liquid ammonia directly into a coil, or by passing wet return gas from the tank through the water cooler. The first has the advantage that it can be connected to a machine working independently from the freezing tank and thus enable the maintenance of very high suction pressure. The only advantage of passing the suction line through the forecooler is that the expansion valves on the tank can be kept open wider, thus insuring that the freezing coils will work throughout their whole length without danger of getting any liquid to the machine. But this same thing can be accomplished far better by means of liquid separators and it is of greater advantage to use the high suction pressure which is possible with direct feeding.

TABLE II. ECONOMIC EFFECT OF OPERATING COMPRESSOR INDEPENDENTLY ON FORECOOLERS WITH HIGH SUCTION PRESSURE

Case I	One Compressor	
	Back Pressure:	
	Ice Tank, 15 lb.	Forecoolers, 15 lb.
	Relative Amount Refrig. Work:	
	Ice Tank, 70 per cent.	Forecoolers, 30 per cent
	Compressor Power per Ton of Refrig.: 1 74	
Case II	Two Compressors	
	Back Pressure:	
	Ice Tank, 15 lb.	Forecoolers, 35 lb.
	Relative Amount Refrig. Work:	
	Main Compressor, Ice Tank 70 per cent.	Auxiliary Compressor Forecoolers 30 per cent.
	Compressor Power per Ton of Refrig.:	
	Main Compressor, 1.21	Auxiliary Compressor, 0.32
	Total, 1.53	
	Saving over Case I, 12 per cent.	
Case III	One Compressor with Multiple-Effect Device	
	Back Pressure:	
	Ice Tank, 15 lb.	Forecoolers, 35 lb.
	Secondary Pressure in Compressor: 27.5 lb.	
	Compressor Power per Ton of Refrig.: 1 1	
	Saving over Case I, 34.7 per cent.	

Refrigerating plants should also be equipped with double-pipe liquid precoolers, cooling the liquid from the temperature of the coldest circulating water down to the temperature corresponding to the highest suction pressure used. In this connection a multiple-effect liquid receiver can also be used, by means of which a greater amount of work can be done at high suction pressure than by the use of the double-pipe cooler alone.

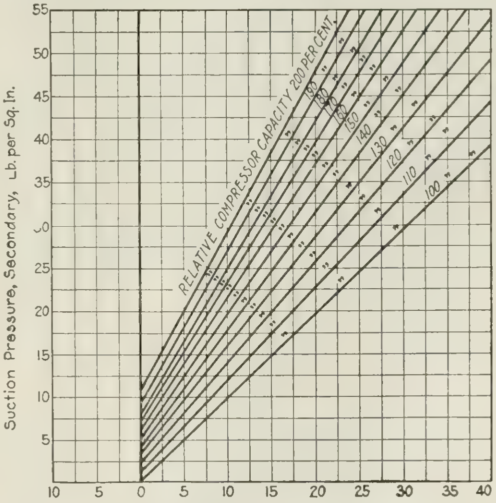


FIG. 4. INFLUENCE OF MULTIPLE EFFECT UPON COMPRESSOR CAPACITY

Every refrigerating plant should have an auxiliary compressor for high-pressure work. The size of this compressor may be relatively small for the reason that it will operate at double its rated capacity. Table II shows what economic effect such a compressor will have by operating it independently on the forecoolers with high suction pressure. In addition to a saving of power equivalent to 12 per cent., the machine capacity will be increased 15 per cent. over all. There is also a decided increase in compressor capacity in cases II and III over I, especially in case III, where, with the same speed, there is a 50 per cent. greater capacity.

One of the most valuable inventions ever made in the refrigerating field is the multiple-effect compressor, which allows gas of higher suction pressure to enter the cylinder after it has been filled with gas of a lower pressure. Although it must be admitted that mistakes have been made in its application, there are installations where it is an absolute success. In a certain plant having sharp freezers and ice tanks, two compressors were operated for a long time, summer and winter, one upon low pressure and the other upon high. After adopting the multiple-effect device, the work was done without the slightest complications. With some compressors on the market it is very simple to use the multiple effect; with others, the arrangement is somewhat complicated. Table II shows the relative benefit derived from operating the forecoolers by means of the multiple effect.

Commenting further upon distilled-water coolers, which ordinarily are nothing but storage tanks with coils immersed, if the suction pressure is raised, the temperature difference will be reduced and a low temperature of the water will not be obtained unless more pipe is put in.

Since the circulation in such tanks is very bad, a much higher heat transmission can be obtained by circulating the water to gain some agitation. Fig. 10 indicates the influence of the multiple-effect method upon compressor efficiency. The curves are based upon 185 lb. condenser pressure and the York Manufacturing Co.'s data as to compressor horsepower required. Fig. 4 indicates the influence of mlltiple effect upon compressor capacity.

New England Engineers Annual Dinner

Over 300 members of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Boston Society of Civil Engineers and other allied societies assembled at the Boston City Club Wednesday evening, Apr. 2, for the tenth annual Engineers' Dinner, which has now become an established event among New England engineers. The speakers were drawn from men prominent in National affairs, educational, manufacturing and engineering circles, and included George H. Moses, United States Senator from New Hampshire; Prof. George F. Swain, of Harvard University; Prof. C. A. Adams, president of the American Institute of Electrical Engineering; H. I. Harriman, president of the Boston Chamber of Commerce; and James J. Storrow, New England Fuel Administrator. Richard Rice, of the General Electric Co., Lynn, Mass., acted as toastmaster.

American Welding Society Holds First Meeting

The first meeting of the American Welding Society was held on Mar. 28, 1919, at the Engineering Societies Building, 33 West 39th St., New York City, and the constitution and bylaws were adopted as recommended by the organization committee. The following officers were elected: President, Comfort A. Adams, Cambridge, Mass.; vice presidents, J. M. Morehead, New York, and G. L. Brunner, Utica; directors for one year—W. M. Beard, New York City; M. H. Roberts, New York City; M. M. Smith, New York City; L. D. Lovekin, Philadelphia, Penn.; Alexander Churchward, New York City; W. H. Patterson, Pittsburgh, Penn.; Walter J. Jones, Philadelphia, Penn.; C. A. McCune, New York City; directors for two years—R. R. Browning, New York City; A. S. Kinsey, Jersey City, N. J.; Victor Mauck, Conshohocken, Penn.; E. L. Hirt, South Bethlehem, Penn.; J. F. Lincoln, Cleveland, Ohio; H. M. Hobart, Schenectady, N. Y.; D. C. Alexander, New York City; H. R. Swartley, Jr., Jersey City, N. J.; directors for three years—L. H. Davis, New York City; E. L. Mills, New York City; D. B. Rushmore, Schenectady, N. Y.; James Burke, Erie, Penn.; D. H. Wilson, Jr., New York City; Hermann Lemp, Erie, Penn.; C. J. Nyquist, Chicago, Ill.; Alexander Jenkins, Baltimore, Md.

It was voted that the charter should be held open for ten days and that those applying for membership in the American Welding Society before Apr. 8 should be considered charter members. At a meeting of the directors in the afternoon, W. E. Symons was appointed treasurer and H. C. Forbes, secretary. The head offices of the society are in the Engineering Societies Building, 39 West 39th St., New York City.

For his inventions in electric welding Prof. Elihu Thompson was unanimously elected the first honorary member of the society. He was characterized by President C. A. Adams as the father of electrical engineering in this country.

Charles H. Manning

Capt. Charles H. Manning, for many years prominent in engineering circles in New England, died at Manchester, N. H., on Apr. 1. Mr. Manning was born in Baltimore, Md., June 9, 1844, and received his early education in that city and in Cambridge, Mass., later entering the Lawrence Scientific School of Harvard University to study civil engineering.

CAPT. CHARLES H. MANNING

During the Civil War he served in the engineer corps of the Navy and became associated with Chief Engineer Isherwood in development work. He was later, in 1881, a member of the Advisory Board that prescribed the specifications for the so-called New Navy.

Leaving the Navy in 1882 after twelve years of continuous service, he accepted the position of chief engineer with the Amoskeag Manufacturing Co., Manchester, N. H., the largest cotton mills in the world, which position he kept until his death. He was the designer of the well-known Manning boiler and was associated with many pioneer power-plant designs, including a 2000-hp. horizontal water turbine, which at the time of its installation in 1885 was the largest of its kind.

He was a past vice president of the American Society of Mechanical Engineers, a member of the American Society of Naval Architects and Marine Engineers and of the American Association of Cotton Manufacturers, as well as a member of several clubs and smaller societies.

New Publications

STEAM ENGINE TROUBLES. By H. Hamkens. Published by The Norman W. Henley Publishing Co., New York City. Cloth; 5 x 7½ in.; 284 pages. Price, $2.50.

Readers of *Power* likely will remember the series of articles on "Steam Engine Troubles," written by H. Hamkens, and published in *Power* during 1917. These articles related almost solely to the Corliss type of engine and dealt with every piece of the engine from the foundation to the steam connections. They were profusely illustrated, and the text was written in that style so appealing to operating and erecting engineers. It was to be expected that such excellent material would be published in book form. And in the book the author has elaborated upon the original matter, making it treat of the slide-valve and other steam engines, as well as the Corliss. The man who operates a reciprocating steam engine will be pleased with the book.

Personals

William L. De Baufre, formerly in the engineering department of the Navy at Annapolis, has resigned to become associated with the Precision Instrument Co. as designing engineer.

C. E. Hague, formerly production engineer of the Mid-West Engine Co., Indianapolis, Ind., has been appointed sales manager of the American Steam Conveyor Corp., Chicago.

Capt. John W. Toyne, Utilities Officer, for the camps Chickamauga Park and Fort Oglethorpe, Ga., has received his discharge from the service and has reopened his engineering office at South Bend, Ind.

Lane Thompson, who has been connected with the sales department of the Lunkenheimer Co. at its headquarters in Cincinnati, Ohio, for many years, has been transferred to Pittsburgh to direct the company's sales in the western Pennsylvania district.

Ira W. McConnell, who has been connected with the Stone & Webster Engineering Corp. since 1912 as consulting engineer and chief engineer successively, and later as works manager and assistant general manager for the American International Shipbuilding Corp. at the Hog Island Shipyard, has been made vice president of Dwight P. Robinson & Co., Inc., constructing and consulting engineers, New York City.

Engineering Affairs

The American Association of Engineers, New York Chapter, will hold a meeting on the evening of Apr. 10, in Room 3, fifth floor, of the Engineering Societies Building, 29 West 39th St., New York City.

Business Items

The Epping-Carpenter Pump Co. announces the appointment of F. S. Healey as manager of sales in addition to his former office of chief engineer, vice E. F. Woods, who is now located in New York as Eastern sales manager. Albert A. Scheuch, of the sales department, has been appointed as assistant sales manager, and Paul D. Goodman, formerly of the McClary Jemison Machinery Co., of Birmingham, Ala., has been added to the sales personnel.

W. E. Becker and **C. R. Smyth** have organized under the name of Becker & Smyth, contracting engineers and sales agents for the Layne & Bowler Co., Chicago, Ill. Mr. Smyth has been for some time special engineer for the above company and previously was connected with the York Engineering and Supply Co., of Houston, Tex., as sales engineer for Busch-Sulzer Bros. Diesel Engine Co. Mr. Becker has been refrigerating engineer and salesman for the York Manufacturing Co., York, Penn., for the last twelve years and treasurer and manager of the York Engineering and Supply Co., Houston, Tex., for seven years prior to organizing with Mr. Smyth.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o b. mines, net tons	$2 15@2 75	$2 80@3 35
Philadelphia, gross tons	4 20@4 90	5 00@5 40
New York, gross tons	4 50@5 25	5 35@5 80
Alongside Boston (water coal), gross tons	6 10@6 85	6.90@7.65

Pocahontas and New River are quoted at $4 70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5 95	$7 80	Pea	4 80	6 55
Egg	5.85	7.70	Buckwheat	3 40	5 15
Stove	6 10	7 95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.80 @ 3 10	2 95 @ 3 25
Clearfield County	2 65 @ 2 95	. .
Reynoldsville	2.65 @ 2.85	2.85 @ 2.95
Quemahoning	2.85 @ 3.10	2.95 @ 3.10
Somerset County (best grades)	2 75 @ 2.95	2.95 @ 3.10
Somerset County (poorer grades)	2.40 @ 2.75	2.75 @ 2.95
Western Maryland	2.50 @ 2.75	2.65 @ 2.85
Fairmont	2.10 @ 2.35	2.35 @ 2.50
Latrobe	2.10 @ 2.25	. .
Greensburg	2.35 @ 2.40	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6 10	7.95	Boiler	2 50	3 50
Nut	6 20	8.05	Barley	2 25	3 15
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2 55	$2.55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2.30	
2-in. lump	....	....	2.15

Williamson-Franklin rate to St. Louis is $1.07½ other rates 92½c.

New Construction

PROPOSED WORK

Conn., Hartford—The American Industrial Bank & Trust Co., 688 Main St., will install a steam heating plant in the 15 story, 56 x 156 ft. bank and office building which it plans to build. Total estimated cost, $600,000. Godly, Haskel & Ledwich, 244 Madison Ave., New York City. Arch.

Conn., Hartford—C. J. Burgess, 64 Brownell Ave., plans to install a steam heating plant in the 3 story hotel which it will build on Washington St. Total estimated cost, $150,000.

Conn., New Haven—The Pallootti-Andretta Co., 630 Chapel St., will install a steam heating plant in the 3 story, 76 x 490 ft. bank which it plans to build on Chapel and Olive St. Total estimated cost, $100,000. D. Guerriero, 647 Main St., Hartford, Arch.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., New York City, will install a steam heating plant in the 5 story, 92 x 193 ft. P. S. No. 20, which it plans to build on North 4th and North 5th St. Total estimated cost, $457,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Brooklyn—The St. Marks Amusement Co., 285 Flatbush Ave., will install a steam heating plant in the 1 story theater which it plans to build. Total estimated cost, $150,000. Carlson & Wiseman, 220 Henry St., Arch.

N. Y., Buffalo—T. & E. Dickinson & Co., 472 Main St., will install a steam heating plant and electric motors for power in the 5 story, 48 x 115 ft. factory and store which it plans to build. Total estimated cost, $170,000.

N. Y., Buffalo—The Sizer Forge Co., 244 Larkin St., is in the market for a 36 in. power shear, for use on 16 gauge metal.

N. Y., Long Island City—The Factory Construction Co., 44 Court St., Brooklyn, will install a steam heating plant in the 4 story, 100 x 200 ft. garage which it plans to build on North Ave. and the Boulevard. Total estimated cost, $350,000.

N. Y., Long Island City—The Famous Players-Lasky Corp., 485 5th Ave., New York City, will install a steam heating plant in the studio and laboratory which it plans to build here. Total estimated cost, $2,000,000. Fleischmann Construction Co., 531 7th Ave., New York City, Engr.

N. Y., Long Island City—The General Carbonic Co., 444 Van Brunt St., Brooklyn, will install a steam heating plant in the factory which it plans to build on 6th St. and West Ave. here. Total estimated cost, $200,000. Austin Co., 217 B'way., New York City, Engr.

N. Y., New York—The Greenwich Development Co., 44 Court St., Brooklyn, will install a steam heating plant in the 1 story, 85 x 140 ft. garage which it will build at 537-549 Broome St. Total estimated cost, $125,000. P. Deckman, Pres.

N. Y., New York—The Langdon Co., Inc., 85 Liberty St., will install a steam heating plant in the 15 story, 50 x 85 ft. store and loft building which it plans to build at 119 West 41st St. Total estimated cost, $600,000. Maynicke & Frank, 25 East 26th St., Arch.

N. Y., Watertown—The Ice Co. of Watertown, 80 Public Sq., plans to build and equip an artificial ice plant having a capacity of 15,000 tons. Address L. Washborn, c/o company.

N. Y., Watertown—The Water Board plans to equip a purification and pumping station with apparatus for making water analysis and alum tests. J. W. Phippen, Supt.

N. J., Trenton—The city plans to install 2 pumps in connection with sewer improvements. J. R. Fell, City Engr.

Penn., Erie—The H. P. Weller Co., 1302 Peach St., is in the market for a punch with 24 inch throat, capacity up to $\frac{3}{16}$ in. through $\frac{3}{4}$ in. iron, driven with 220 a.c. 3 phase, 60 cycle motor.

Penn., Philadelphia—The Finance Co. of Pennsylvania, Finance Bldg., will install a steam heating system in the 21 story, 35 x 90 ft. office building which it plans to build at 1416-18 South Pennsylvania Ave. Total estimated cost, $1,500,000. Hoffman & Co., Finance Bldg., Arch.

Penn., Pittsburg—McGovern & Co., Union Arcade Bldg., is in the market for a [illegible] Chambersburg steam hammer [illegible].

Fla., Bushnell—The city will require equipment in connection with installing [illegible] current for electric lights. Estimated cost, $10,000.

Tenn., Kingsport—The Kingsport Utilities Co. plans to remodel and improve its power plant here and is in the market for power plant equipment to include the installation of Curtis Type Turbines, generating 10,000 k.w. C. Thornburg, Ch. Engr.

Tenn., Kingsport—The Union Dye & Chemical Corp. plans to build an ice plant and is in the market for machinery for same. J. E. Wilkinson, Ch. Engr.

Ohio, Cleveland—B. F. Keith Co., Hippodrome Bldg., will install a steam heating plant in the theatre and office building which it plans to build at 631 Prospect Ave. Total estimated cost, $1,500,000.

Ohio, Cleveland—The St. Luke's Hospital Association, 6606 Carnegie Ave., will install a steam heating plant in the hospital addition which it plans to build. Total estimated cost, $500,000.

Ohio, Lorraine—The Board of Education will install a low pressure heating plant in the 1 story, 125 x 200 ft. school which it plans to build. Total estimated cost, $125,000. Perkins, Fellows & Hamilton, 814 Tower Court, Chicago, Ill., Arch.

Ohio, Oxford—The city will receive bids about May or June for constructing 1 mi. of high tension transmission line, installing new electric pumps, and building 200,000 gallon elevated tank. Estimated cost, $40,000. L. A. Boulay Co., 1250 Nicholas Bldg., Toledo, Engrs.

Ind., Alexandria—The Ziegler Manufacturing Co. is in the market for a No. 00 Brown and Sharpe automatic screw machine, a No. 3 La Salle double and surface grinder and a Stoll overdriven power squaring shear for 73 x 3⅛ in. soft steel.

Ind., Gary—The Eagle Theater Co. will install a steam heating and automatic ventilating system in the 1 story, 75 x 125 ft. theater which it plans to build on 16th St. and B'way. Total estimated cost, $125,000. D. S. Klafter, 64 West Randolph St., Chicago, Ill., Arch.

Mich., Detroit—The Board of Water Commissioners, 232 Jefferson Ave., will soon award the contract for furnishing 1 power hammer for forging iron up to 3 in. diameter.

Mich., Detroit—The Detroit Edison Co., David Whitney Bldg., plans to build a 30,000 k.w. addition to the Delray Power Plant, on West Jefferson Ave.

Ill., Chicago—The Board of Education has awarded the contract for installing a steam heating plant in the addition to the Davis Schol on West 39th St. and Sacramento B'lvd., to the Arcade Steam Heating Co., 126 West Kenzie St. Estimated cost, $22,316.

Minn., Brainerd—The Crow Wing County will install a steam heating plant and mechanical ventilation system in the 3 story court house which it plans to build. Total estimated cost, $250,000. Alden & Harris, 1011 New York Life Bldg., St. Paul, Arch.

Minn., Buhl—The St. Louis Co. School Dist. No. 3 will install a steam heating plant and mechanical ventilating system in the 3 story high school addition which it plans to build on Chestnut St. Total estimated cost, $275,000. A. W. Kerr & Co., 524 Metropolitan Bank Bldg., Minneapolis, Arch.

Minn., Chisholm—The city will install a steam heating plant with mechanical ventilating system in the 2 story, 85 x 125 ft. auditorium which it plans to build on Main St. Total estimated cost, $100,000. A. Puck, Tarrey Bldg., Duluth, Arch.

Minn., Red Wing—The city will soon award the contract for the construction of a 100 x 100 ft. light and power plant; also new district system. Estimated cost, $350,000. L. P. Wolff, 1000 Germania Bldg., St. Paul, Engr.

Neb., Clarkson—The city will soon award the contract for rebuilding electric light and pumping plant. Henningson Engineering Co., 1122 Farnham St., Omaha, Engrs. Noted Oct. 15.

Mo., Columbia—The University of Missouri plans to build alterations to its power house. Estimated cost, $20,000. A. R. Hill, Pres.

Mo., Fulton—E. E. Reed, Pres. Westminister College, will receive bids about April 20 for the construction of a heating plant on the campus. Estimated cost, $25,000.

Mo., Richmond—The City Council is having plans prepared by Black & Veatch, Engrs., Interstate Bldg., Kansas City, for the construction of a new steam pumping plant at the city waterworks.

Ark., Springdale—The city plans to build a lighting plant. Estimated cost, $50,000. W. L. Winters, 700 South 20th St., Ft. Smith, Engr.

Tex., Corsicana—The Oil City Iron Works Co. is in the market for a power hammer, 100-200 lbs. capacity.

Man., Winnipeg—The Department of Public Works, Ottawa, Ont., will receive bids until April 16 for the construction of a 1 story, 110 x 122 ft. extension to the power house and laundry at the Military Hospital at Tuxedo. Equipment including 1 oil separator 3 x 4 in. automatic pressure reducing valve; two 10 x 14 x 16 steam driven single cylinder double acting, low duty, packed piston vacuum pumps; one 2 in., 2 stage vertical split case horizontal centrifugal pump; 1 hot water circulating pump; one 1½ in. horizontal centrifugal pump; 2 alternating motors, 2 hp., 3 phase, 220 volt, 60 cycle, 1800 r.p. min., will be installed in same. Total estimated cost, $75,000. R. C. Wright, c/o Dept. of Pub. Wks., Arch.

B. C., Vancouver—Gardiner & Mercer, Archts., 827 Birks Bldg., will receive bids about Apr. 10 for the construction of a 2 story 64 x 125 ft. boiler and blacksmith shop for the Mainland Engineering Co., 132 Railway St., in connection with the engineering works which it plans to construct on Georgia St. near Coal Harbor. Total estimated cost, $70,000. Noted Mar. 18.

CONTRACTS AWARDED

Mass., Cambridge—F. H. Dow Co. has awarded the contract for the construction of a 5 story, 60 x 100 ft. factory on Main St., to include power house and refrigerating plant, to W. M. Bailey Co., 88 Broad St., Boston. Total estimated cost, $150,000.

R. I., Providence—The Providence Ice Co., 17 Exchange St., has awarded the contract for the construction of a 2 story, 90 x 135 ft. plant for the manufacture of artificial ice, to the Lord Construction Co., Fields Point. Estimated cost, $30,000.

Ill., Chicago—The Chappell Ice Cream Co., 1901 Webster St., has awarded the contract for the construction of a 1 story, 25 x 48 ft. garage and power house, to the Menke Thielberg Co., 139 North Clark St. Total estimated cost, $20,000.

Ia., Davenport—The Tri City Plate Ice & Cold Storage Co., 1433 West 2nd St., has awarded the contract for the construction of a 1 story, 35 x 55 ft. ice plant, to the Vilter Manufacturing Co., 872 Clinton St., Milwaukee, Wis. Estimated cost $50,000.

Minn., Duluth—The Clarkson Coal Co., foot of Birch Ave., Rices Point, has awarded the contract for installing electric convertor equipment, to the Westinghouse Electric Co., 605 Providence Bldg.; installing machinery for loading and unloading coal at dock, to the Mead, Morrison Mfg. Co. Total estimated cost, $125,000.

Mont., Miles City—The city received following bids for installing equipment in electric light and power plant: (a) 750 k.w. turbine generator, (b) 2 boilers, (c) stokers, (d) ash handling equipment, from the Westinghouse Co., (a) $16,972 (geared type), (a) $23,200, (direct connected), (c) $6635 (on Westinghouse); General Electric Co., (a) $17,825 (direct connected); Allis-Chalmers Co. (a) $17,900 (direct connected); Northwestern Electric Equipment Co. (a) $19,794 (direct connected) (b) $18,900 (on Murray), (c) $9116 (on combustion engine); Heine Safety Boiler Co. (b) $16,100 (on Heine); Babcock & Wilcox (b) $14,575 (on Sterling); R. B. Whitacre Co., (b) $17,630 (on Franklin), (c) $300, (on Riley), (d) $5032; Link-Belt Co. (d) $5461.

Que., Montreal—The city has awarded the contract for installing boilers at the waterworks to carry out tests with fuel oil, to the Imperial Oil Co., 918 St. Patrick St. P. E. Mercier, Engr. of the Dept. of Pub. Wks.

Read the

SEARCHLIGHT SECTION

The
"Opportunity" advertising
of the
Power Plant Field

See pages 87 to 94

POWER

Volume 49 New York, April 15, 1919 *Number* 15

Making a Hobby of Work

"TO SEE that man carry bricks is like reading poetry," observed one who was watching a large building under construction.

That was a compliment—as fine a compliment as could be paid anyone. Perhaps the man who was doing the carrying would not have appreciated it; but the chances are that he would, though probably his life had little time in it for poetry.

What a wonderful thing it would be if all of us could make our daily tasks smooth and enjoyable, so that we could look forward to them with pleasure, instead of—as is too often the case—just so much time taken out of our lives.

Many men toil day after day at work that is disagreeable, never realizing that other men have done the same thing before, and often are right beside them, enjoying it immensely. What is more, many men engaged in hard physical or mental effort actually take keen interest and pleasure in shop or office.

Each appreciates the progress of the department in which he happens to be employed, just as though the whole success of the thing depended upon him alone. Each is enthusiastic over any special achievement in his branch of the work and gratification beams from him when he has done something particularly well.

These men are not boot-lickers, looking for special approbation from the man next higher up. They are simply those who gain supreme satisfaction in life from good work well done. Some of them are blessed by heaven with the capacity for being more than contented with every opportunity for doing something, for producing something, for gaining more of the feeling that they have advanced the world another little notch on its way to perfection; and it means more than passing satisfaction to them to feel that those who are to follow will say, "He who went here built a good road."

But not all of these fortunate men have their contentment sent to them from the gods. Some discover it for themselves. Take the case of a man who had gone through years of his life before he learned the secret. This particular man came across a problem that seemed beyond his knowledge and experience; so he referred it to his foreman. But for some curious reason that he could never explain, he became interested in learning who would find the answer to the thing that had puzzled him.

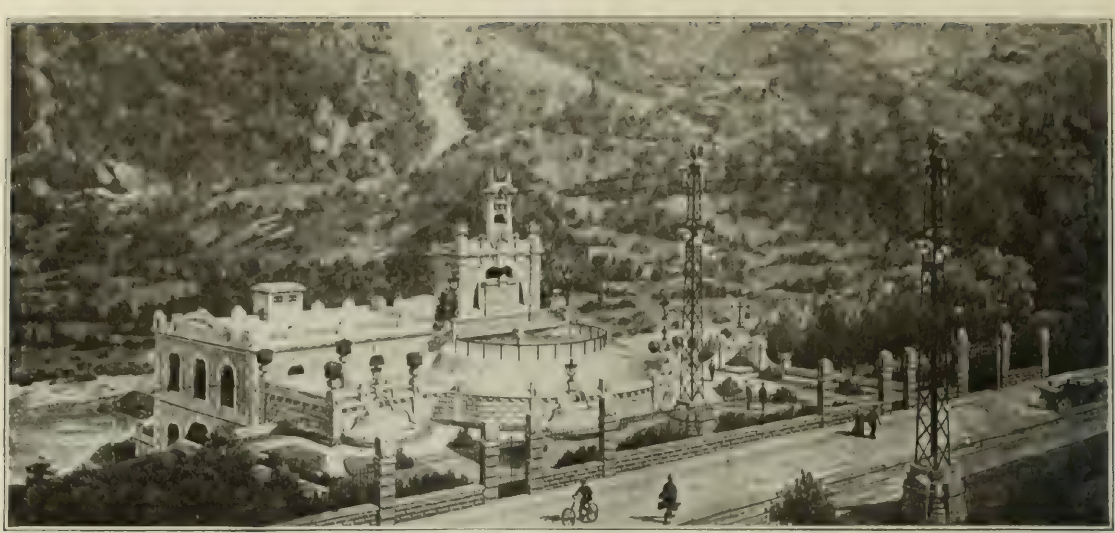
He saw the paper go from the foreman to the superintendent and made an excuse to follow it. He passed the glass door as the big man looked at the sheet, wrinkled his brows and reached for a book. This action made him hesitate so that he might see what followed, and he was asked to come into the office. The superintendent talked the matter over with him, and showed him how to work out the problem; and then he had the surprise of his life, for the book that was being consulted was one that he already owned, but which had lain on his mantelpiece, untouched, for more than a year.

He saw how easily the foreman or he himself could have settled the question had either of them thought to use common sense, and that was the turning point in his career. When he reached home that night, he took down his copy of the book and dug out some practice problems. Within a week, since he was already familiar with the shop practice, he had practically mastered the subject matter and had inquired at the library for more along the same line. He was surprised to find that there was so much interesting and helpful material to be easily secured, and from that day he was a student.

It is doubtful whether other men have as good a time at the theater as this man gets from his evenings of study. He has made the thing a hobby, and it is an inspiring sight to see the change in him. Whereas he once honestly dreaded his work, now he is eager for new things to come up for his wits to tackle. He has been promoted a number of times, but the joy of his work is no longer wholly in the prospect of a fat envelope on Saturday. It is in the daily task as it comes to him. He has found freedom by becoming so familiar with the problems in his department that they no longer hold any terrors for him. Obstacles are things of special interest.

If this were merely a fairy tale and were to have a moral, it would be, "Make your work your hobby." But those who will not see a moral until it is pointed out will not act on it afterward; so the reader may draw his own.

Contributed by Benjamin Ogden Wilkins



Hydro-Electric Development at Vernes

VIRTUALLY abandoned before the war on account of apparently insurmountable ownership difficulties, this project was the object of a new plan conceived and organized at the end of 1916 by C. A. Keller, of the Société des Etablisséments Keller & Leleux. Begun Apr. 1, 1917, the works were carried out in sixteen months, including a winter during which a large part of the outside operation was suspended. All the technical studies of the project were made by the company's organization.

The hydraulic works were put under pressure on July 27, 1918, without incident. Labor was supplied almost exclusively by German prisoners. In particular the tunnel was constructed by them under the direction of only a few skilled workmen.

The Vernes plant required neither dam nor intake since it uses the discharge of the Livet plant, nearly half a mile distant. The supply of water to Vernes is by a continuation of the discharge channels of the Livet plants, which for this purpose have been continued under the present plant without interrupting its operation. The water thus collected is led first to an intermediate open chamber supplied with a surface spillway for part-load operation and then is carried through a tunnel 620 m. (2034.22 ft.) long and 16 sq.m. (172.2 sq.ft.) in cross-section excavated entirely in rock, and continued by a reinforced-concrete conduit of 132 m. (433.09 ft.) length and 3.6 m. (11.81 ft.) diameter built at the bottom of a trench 11 m. (36.09 ft.) deep and subsequently backfilled. The conduit passes under the national highway and under the railway, both carried by a reinforced-concrete bridge, and ends at a circular forebay.

The reinforced-concrete conduit is under pressure due to a head of 8.5 m. (27.89 ft.) at its lower end. Building the hydraulic works offered serious difficulties because of the depth below ground, which made it necessary to raise most of the excavation and the water through shafts over 10 m. (32.81 ft.) deep. Moreover, the reinforced-concrete conduit had to be built at the bottom of a deep timbered and strongly braced trench.

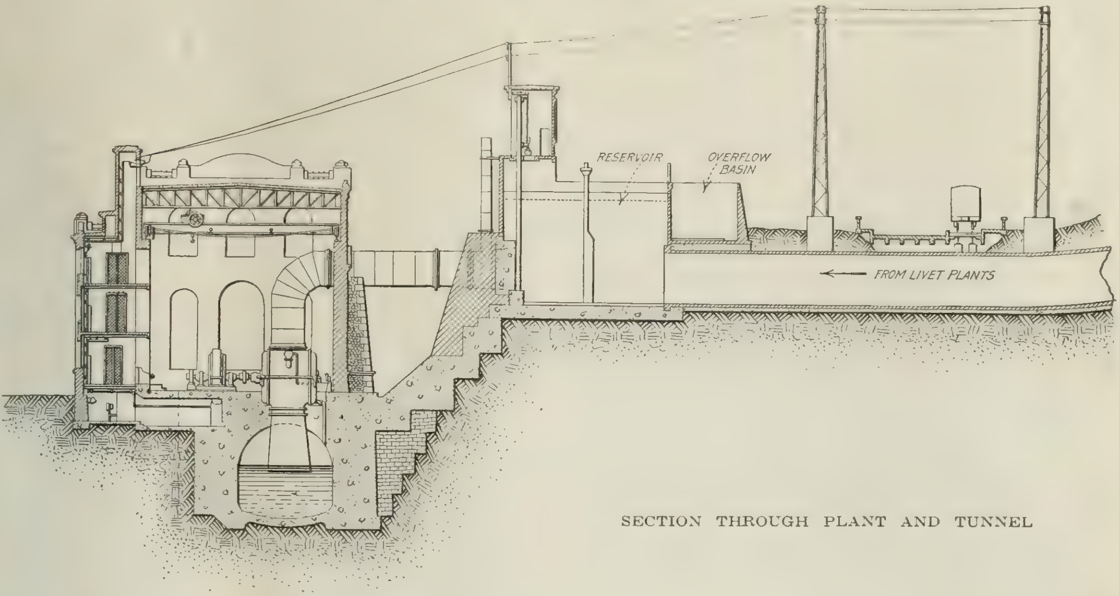
The entire tunneling was carried on with compressed-air tools, requiring the installation of three electric compressor plants, aggregating 200 horsepower.

The forebay is of reinforced-concrete and consists of a circular supply reservoir for the penstocks, with the upper rim forming a spillway and an exterior basin receiving the overflow to lead it to a discharge chamber from which pass two steel discharge conduits of 2 m. (6.56 ft.) diameter. This arrangement permits of obtaining a spillway with the necessary surface area to provide for reduction of load or shutdown of the plant and to make sure of the certain and dependable carrying off of the large flow that thus might be suddenly set free. The depth of the supply conduit and its distance from the natural watercourse made it impossible to arrange an ordinary surface spillway. The outer basin, receiving the water from the spillway of the forebay, supplies the two discharge pipes, whose outfall velocity is naturally controlled by the discharge and whose degree of filling determines the discharge velocity. Its operating range has as a maximum the filling of the basin, and the discharge tubes are then under pressure and flows as free orifices. In the latter condition the discharge velocity is 15 m. (49.22 ft.) per sec. and the full flow can be discharged. To check the discharge velocity, the outlet openings are submerged in the waters of the discharge channel. This general arrangement offers the advantage of diverting the surge waters to the dis-

DISCHARGE CONDUITS

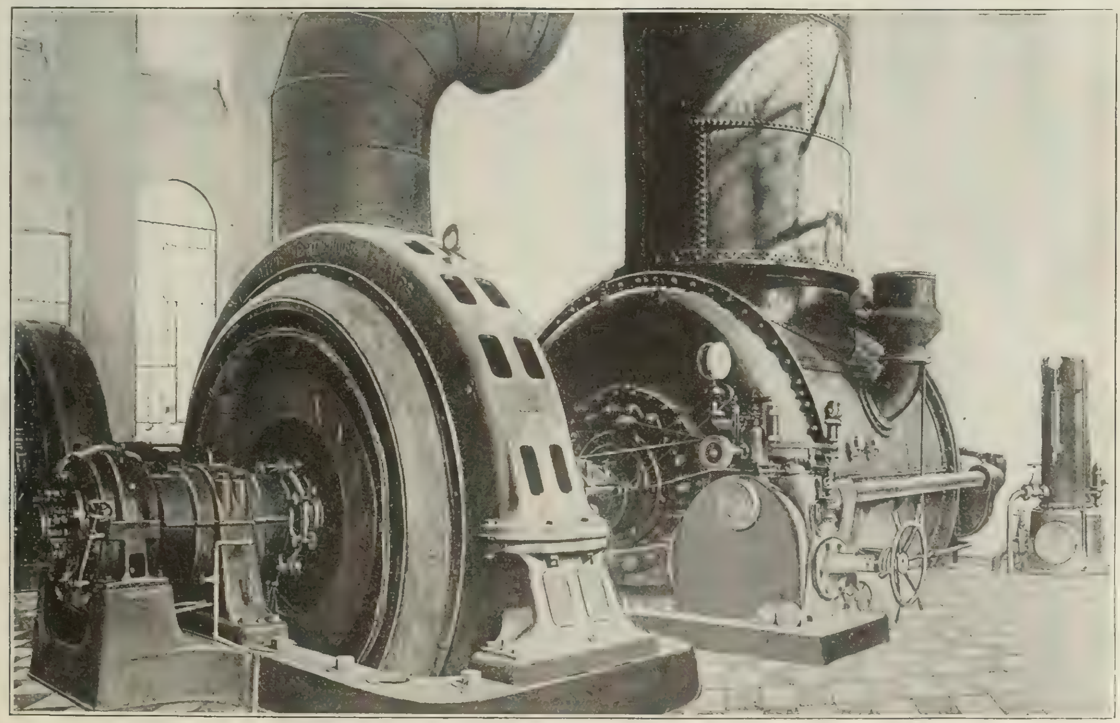
charge canal, in such a way that the variations of load do not cause variations of flow and in consequence no disturbance is occasioned the operation of the water-power plants downstream.

The downstream wall of the forebay contains two gates, each controlling a steel conduit of 2.5 m. (8.20 ft.) diameter, which feeds a turbine of 3500 hp. These gates are operated electrically by means of two motors of 25 hp. each. They are separately controlled from the switchboard of the generating station.



SECTION THROUGH PLANT AND TUNNEL

Each unit consists of a Francis turbine connected to a single-phase alternator. The controls of the guide vanes are rigidly coupled by an exterior shaft receiving its movement from a regulator through a servo motor, operated by oil under pressure, made subject to manual control at the switchboard by means of a small electric motor. The oil pressure is obtained by compressed air stored in a reservoir fed by a compressor driven from the turbine shaft. The alternators each have a capacity of 3000 kv.-a. and furnish current to the sys-



HYDRAULIC TURBINE-DRIVEN GENERATING UNITS AT THE VERNES PLANT tem at 5000 volts and 25 frequency, at a speed of 375 revolutions per minute.

PLANT DATA

Flow per second	35,000 liters	(1235.85 cu.ft.)
Head	20.5 m.	(67.26 ft.)
Underground canal below the plant, length	208 m.	(682.45 ft.)
[illegible]	16 sq.m.	(172.2 sq.ft.)
[illegible]	620 m.	(2034.22 ft.)
Diameter [illegible]	2.5 m.	(8.20 ft.)
Power of each of the [illegible] units	3,500 hp.	
[illegible]	350	
Total [illegible] days	167,000	

The two units feed in parallel a double transmission line to the new works of "Champ de L'Eglise," in conjunction with the present Livet works, the units of the Vernes and those of the Livet plants operating in parallel.

The switch and control board has all its operating panels on the ground floor. A storage battery supplies the relays of the automatic switches. This battery is charged by direct current brought from the Livet plants by a special line.

At the Champ de L'Eglise plant is a series of electric furnaces of 2750 hp. and one of 3500 hp., producing 80 tons of electric steel daily. This plant is to include in the future a steel works, forge shop and rolling mill. Its present ground area is 14,000 sq.m. (150,640 sq.ft.).

High-Pressure Steel Economizers at Kansas City

THE trend of present day boiler practice is not only toward larger boilers and higher pressures but also higher ratings. These conditions lead to high flue gas temperatures and great weight of gases passed in a unit time interval, so that economizers are being extensively used especially with installations of large boilers.

While cast iron, the usual material of which economizers are built, gives efficient and safe service for pressures now common, engineering opinion is not completely satisfied that it will do for pressures of 300 lb. and more. Steel is not so durable as cast iron for economizers, but with reasonable care it is safer for very high pressures. The whole economizer might be made of steel but for one chief reason; namely, the condensation of the vapors in the flue gas on the relatively cold tubes, resulting in seriously rapid corrosion of these tubes. This corrosive action is especially bad if the coal is high in sulphur. Cast iron withstands this corrosive action much better than does steel.

The use of steel for economizers is not new. Continental Europe used it for this purpose several years ago, and experience has confirmed that it corrodes much more rapidly than cast iron. However, if engineers are going to use boiler pressures up to 1000 lb., as is discussed, cast iron will not be safe. Just where it becomes unsafe—that is, at just what pressure—is a question which those interested in economizers would like to hear discussion upon. Those familiar with European experience with steel economizers are invited to write for publication in *Power*.

In a new power station now being erected for the Kansas City Light and Power Co., Sargent & Lundy, Engineers of Chicago, have met the economizer problem for a high-pressure installation in an interesting manner, by dividing the economizer into two sections, a high-pressure and a low-pressure section. The cold part of the economizer is of cast iron and will be operated at low pressure—only a little above atmospheric. The hotter part of the economizer is the high-pressure section, which is of steel construction something like a section of a Stirling boiler. The whole arrangement is as indicated in the drawing on the next page. The feed water will be pumped first through the low-pressure economizer into a tank which forms the suction tank for the boiler feed pumps by which it will be pumped through the high-pressure economizer and into the boiler. The economizers are so proportioned that the water will be heated in the low-pressure economizer up to not over 200 deg. F., probably between 170 and 190 deg., which will prevent the formation of steam in the low-pressure economizer and put the water into the high-pressure economizer at a temperature sufficiently high to prevent any condensation on the tubes of the high-pressure economizer. The condensation and consequent corrosion is thus confined to the low-pressure sections where leakage and deterioration are much more easily controlled.

The boilers are of the Babcock & Wilcox, cross drum, "Alert" type and are each 42 tubes wide, 14 tubes high with 20-ft. tubes all connected to one 60-in. drum. The boilers have 13,512 sq.ft. of heating surface each, and are rated at 1351 hp. Each boiler has a superheater designed to give 250 deg. F. superheat when the boiler is evaporating 90,000 lb. of water per hour. The working pressure is 300 lb. The chain-grate stokers are each 120 in. by 210 in. long.

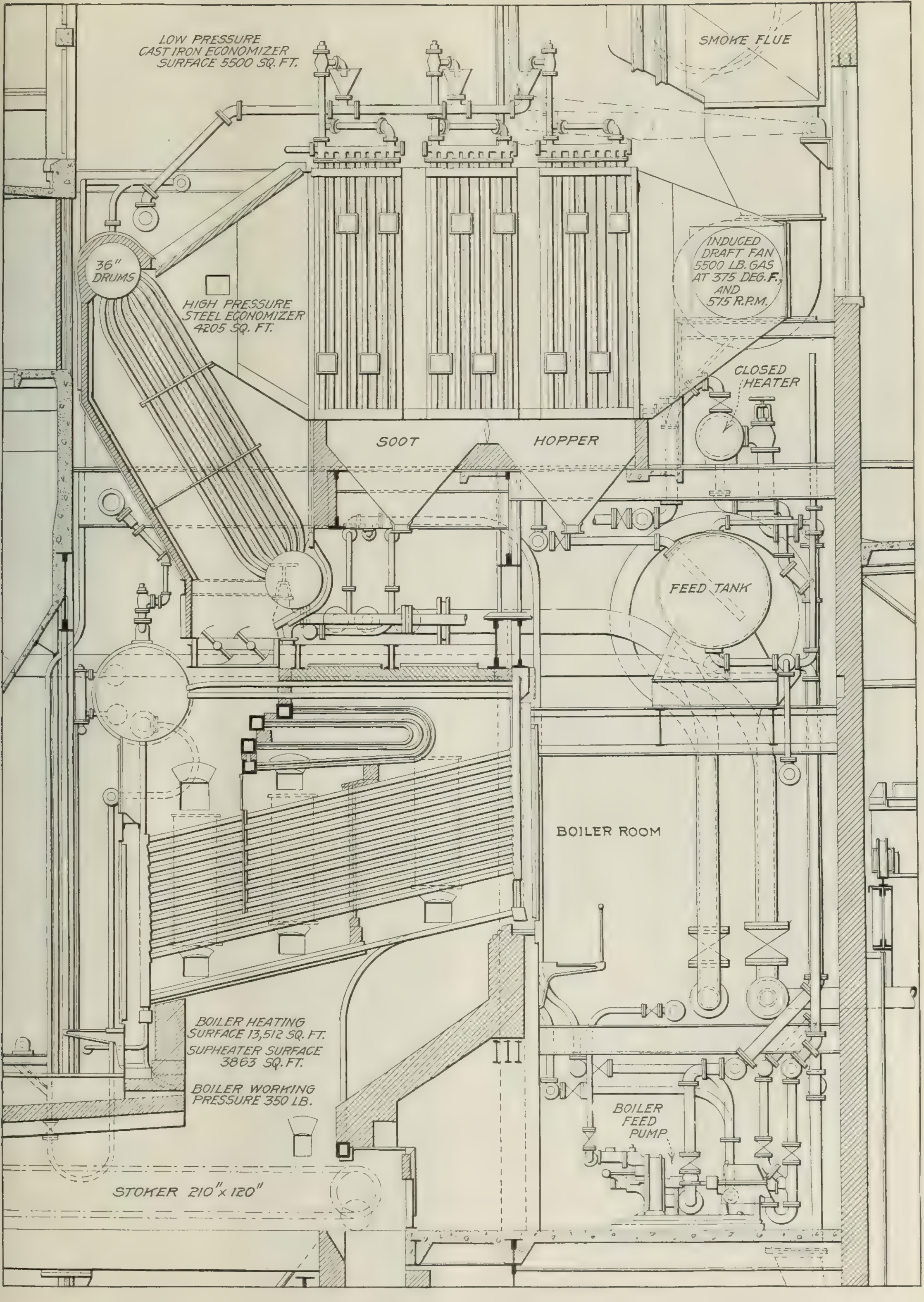
The high-presure economizer is made up of two 36-in. drums, 23 ft. long, having 306 3¼-in. cold-drawn seamless tubes ¼ in. thick, arranged in 38 sections of 8 tubes each, front to back. Each high-pressure economizer contains 4205 sq.ft. of heating surface. Notice that this economizer is baffled so that the gases pass over the tubes transversely three times. It is supported from the building steelwork, the support being at the upper end so as to be free to expand downward. The economizer is inclined 35 degrees.

Each low-pressure cast-iron economizer, of the Green type, has 336 12-ft. tubes, 7 tubes per header, with a total of 5500 sq.ft. of heating surface. Each economizer is 16 ft. 11 in. long and the outside over-all width is 16 ft. 2 in. The induced fans, one for each boiler unit, are of the multivane type, with two single inlets, driven by one 150-hp. slip-ring induction motor. Each boiler and economizer is intended to evaporate 80,000 to 100,000 lb. of water per hour, going up to 120,000 lb. per hour when forced.

Sargent & Lundy have one high-pressure all-steel economizer in operation and so far have experienced no difficulties from corrosion of the outside of the tubes. In this economizer the water has been kept at about 125 deg. F. entering the economizer, a heater being used to get the water up to this temperature. There are some evidences of corrosion, but it is expected that this can be kept down so that it will not be serious.

Each boiler has six soot-blower (Diamond) units on each side, with 21 nozzles to each unit; the high-pressure economizer has six units of 19 nozzles each.

The rotary system of oil-well drilling has been in common use only about 15 years. Its great advantage is speed in soft or caving ground.



HIGH- AND LOW-PRESSURE ECONOMIZERS, KANSAS CITY LIGHT AND POWER CO.

United States Nitrate Plant, No. 2

at Muscle Shoals, Ala.

CONDENSER EQUIPMENT

By Charles H. Bromley

CONDENSER INTAKE, SHOWING STOP-LOGS AND DISCHARGE TUNNEL

The 60,000-kw. unit has four condensers, each of 25,000 sq.ft. of Muntz metal tube surface. The circulating-water pumping capacity is 132,000 gal. per minute, 44,000 gal. per minute spare. A forebay with stop-log gallery constitutes the circulating-water inlet. The condensers, with 30 ft. 5⅝ in. long exhaust connections, are hung from the turbine foundation with no supports under the condensers.

THE 60,000-kw. three-cylinder, pure-reaction turbine is served by four surface condensers each of 25,000 sq.ft. of tube surface, two condensers being connected to each of the two double-flow low-pressure elements of the turbine.

An intake tunnel is not used, as is customary. A forebay has been created, as shown in the headpiece. The water from the river enters the forebay via the stop-log gallery, Fig. 2. Each of the eight inlet openings in the gallery has a front resting on two tanks and which floats up and down with the rivel level, guides for the float being made in the concrete piers. Section and plan views of one of these floats are shown in Fig. 7. The concrete piers have a total height of 21 ft. each up to the floor or walk level; all concrete used in its construction is of 1 : 2½ : 5 mixture. Practically all the wood used is creoseted yellow pine. Each pier is 3 ft. thick and the distance, in the clear, between piers is 8 ft. The stop logs are 1½ by 10 inches.

The purpose of the floats is to draw water into the forebay from about 3½ ft. beneath the surface of the river and thus provide a means of keeping floating débris out of the forebay.

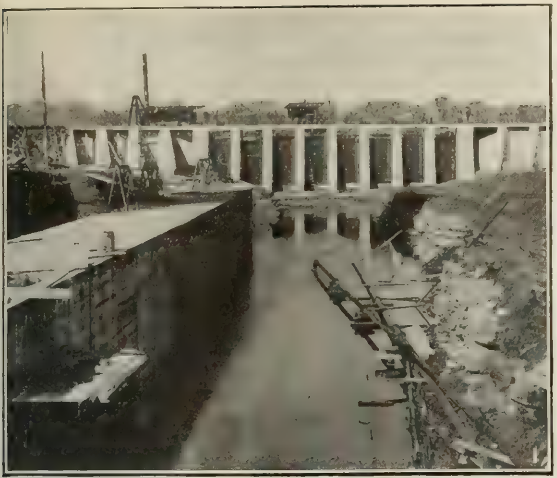
Because of the filled-in bank on the upstream side of the forebay the tendency is to cause the river current to throw floating débris out into the steam and clear of the stop-log gallery.

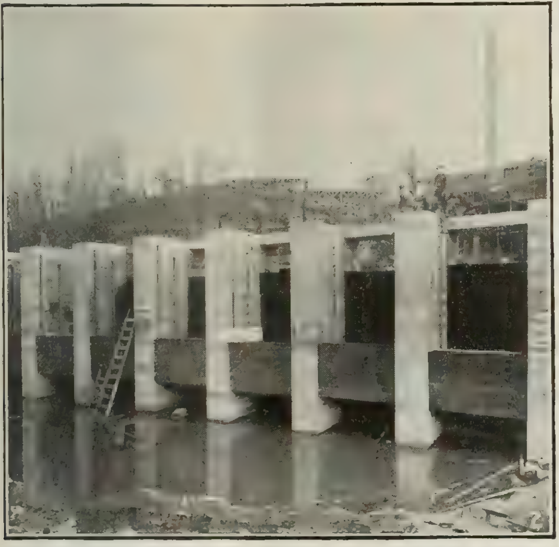
At the power house are six 78 in. wide, vertical, traveling screens. Fig. 4 shows their location. Each screen is 6 ft. 4¼ in. wide between centers of the chain, 45 ft. long between centers of head and foot shafts; these operate at a speed of about 9 ft. per minute. They are made up of continuous screen trays 78 in. wide, 18 in. pitch, mounted on two strands of 18-in. pitch steel bar link, bronze-bushed roller chains with solid iron rollers. The screen trays are made of angle-iron frames with No. 18 U. S. S. gage galvanized steel wire cloth with ½-in. clear openings.

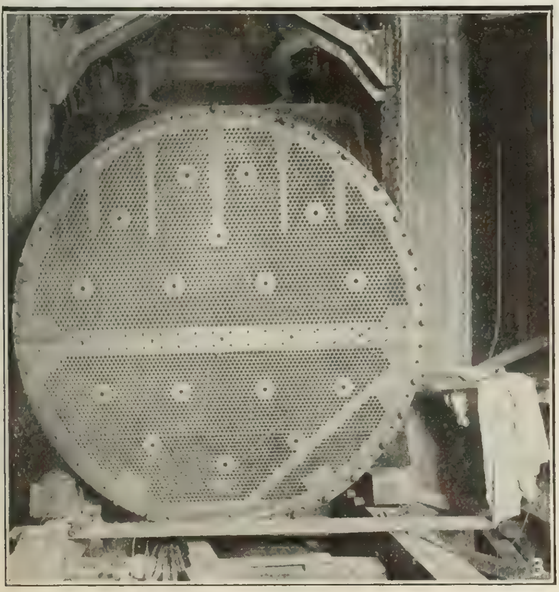
The six screens will pass 515 cu.ft. of water per second at a water level of 12 ft., based on a velocity of 2 ft. per sec. The six screens are driven through a common lineshaft with jaw clutches by two 10-hp. motors running at 865 r.p.m. The headshafts are driven from the lineshafts by bushed-roller chain drive through incased speed-reducing transmission at each end of the lineshaft with flexible couplings to the motors. Each speed-reducing transmission is connected to the lineshaft through spur gears having breaking-pin hubs. The total weight of the screens is 131,000 pounds.

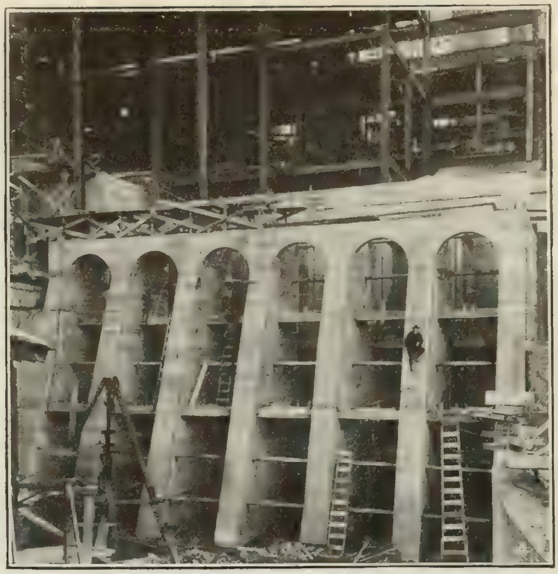
Four centrifugal circulating pumps, each driven by a 550-hp. motor at 700 r.p.m. have capacity of 44,000 gal. per minute each, total 176,000 gal. per minute, or 87,964,800 lb. per hour at 60 deg. F. One of these pumps is a spare. This will mean a flow of about 400 c.f.s. in the intake. The level of the intake water below the discharge-water level is 3.5 ft., and the level of the cold well below the center line of the pump is 15 ft. The total pumping head, exclusive of pumping head through the condenser, is 9 feet.

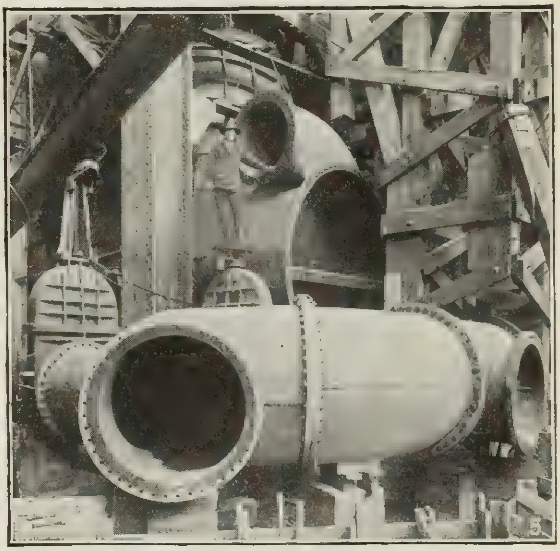
The intake tunnels and wells in the station are so











FIGS. 1 TO 5. INTAKE, CONDENSER HEAD AND SOME OF THE 60-IN. PIPING AT MUSCLE SHOALS

Fig. 1—Looking down the intake toward the stop-logs; the discharge tunnel is shown at the right. Fig. 2—The stop-logs from the river side; note the floats which skim off the floating débris. Fig. 3—Showing the tube sheet of the condenser. Fig. 4—Close-up view of the concrete structure for the revolving screens; note the man at the left. Fig. 5—Showing part of the condenser and the 60-in. circulating-water piping.

Photographs by courtesy of J. G. White Engineering Corporation.

arranged that they may be conveniently flushed and cleaned. The arrangement of the pumps is desirable from the operating viewpoint particularly, as shown in Fig. 6, which gives the important dimensions.

Rubber expansion joints are used in the circulating-water piping to care for distortion. A hoist is provided over each circulating pump to lift off the cover with facility.

The air pumps are of the LeBlanc type, each of 2000 gal. per minute water; the discharge head including friction is 4 ft., and the suction lift including friction is 10 ft. The pumps are each driven by a 100-hp. motor at 700 r.p.m.

Condensate pumps have capacity for 400,000 lb. per hour, each at head of 96 ft., with a submergence head of 3½ ft. Each is driven by a 75-hp. motor at 1750 r.p.m. and Cincinnati, Ohio, where similar conditions obtain.

The condensers will give the following performance:

When condensing 400,000 lb. of steam per hour:

Temperature of Water Deg. F	Vacuum In.
80	28.45
60	29.15
40	29.30

When condensing 500,000 lb. of steam per hour:

Temperature of Water, Deg. F	Vacuum, In.
80	28.30
60	29.05
40	29.25

When condensing 600,000 lb. of steam per hour:

Temperature of Water, Deg. F	Vacuum, In.
80	28.15
60	29.00
40	29.20

The manner of supporting the condensers was given unusual consideration jointly by the purchaser, the J. G. White Engineering Corporation, the turbine designer and the condenser builder. The condenser and connecting steam passage are hung from the turbine foundation, being keyed to hanger girders at all four sides with keys 26¼ in. long, 4 in. wide, 2½ in. thick, of forged steel and made to conform to the A.S.T.M. specifications. There is an expansion joint between the exhaust connection and the turbine exhaust to provide principally for expansion along the tubrine

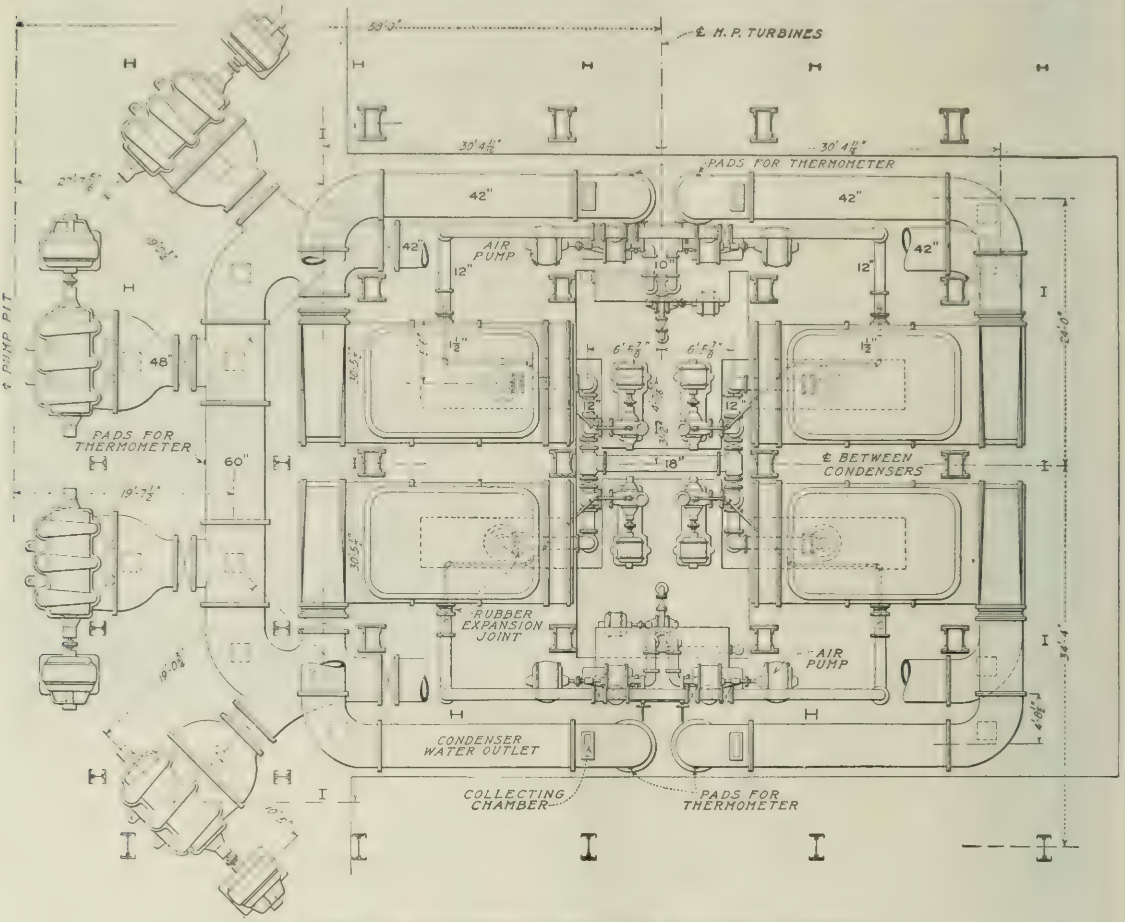


FIG. 6. PLAN OF CONDENSER PIPING, CONDENSERS AND PUMPS

There are four 25,000 sq.ft. condensers served by four circulating pumps (one a spare), each of 44,000 gal. per min. capacity, discharging into a ring supply pipe common to all four condensers.

The four 25,000-sq.ft. condensers have 5285 1-in. Muntz-metal tubes each, 18 ft. 3⅜ in. long, arranged in the heads as shown in Fig. 3. The weight empty is 220,000 lb.; full of water, 405,000 pounds.

The condenser inlets are 31 ft. below flanges of the exhaust openings of the low-pressure elements, the castings forming these steam passages being so well done as to call for commendation. The losses in these passages will likely be negligible, basing judgment on performances in the large plants at Windsor, W. Va., axis. The exhaust connection pieces are supported by steel straps suspended down from the steel work of the turbine foundation. The condenser is suspended from the exhaust connection and there are no supports beneath the condenser.

The next article deals with heat-balance studies of the station and is accompanied by numerous curves giving all the data that the consulting, designing and operating engineers desire. The article was prepared for *Power* by W. A. Shoudy and H. C. Lockwood, of the Mechanical Division, J. G. White Engineering Corporation, who built the station.

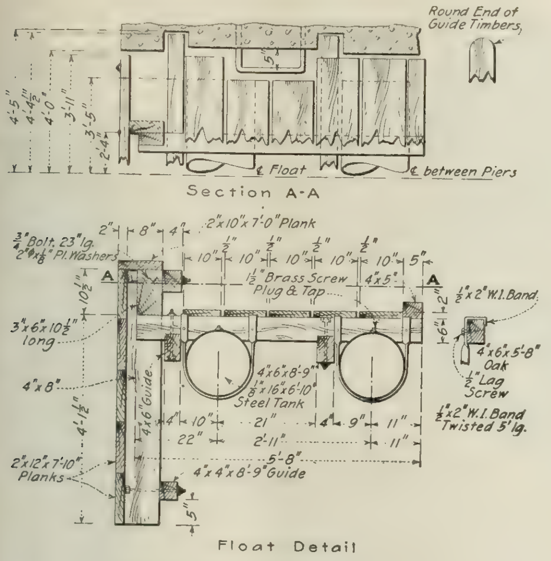


FIG. 7. DETAILS OF FLOAT USED IN THE STOP-LOG CONSTRUCTION

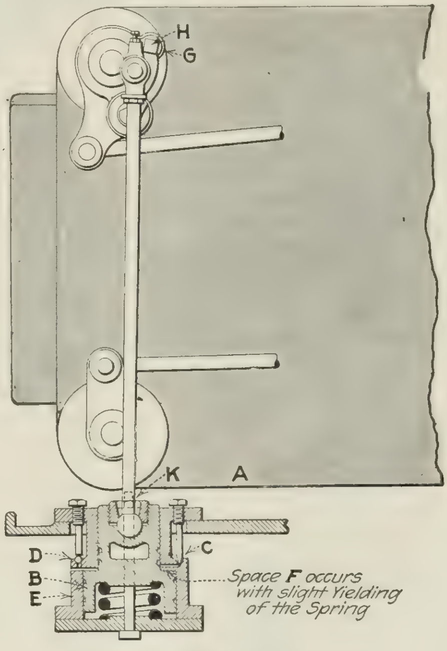
Miller Vacuum Dashpot

A type of Corliss valve gear coöperating with a vacuum dashpot, having certain new features perfecting the operation of a Corliss engine for the requirements of high speed, high pressure, long range, and close regulation, has recently been patented by F. B. Miller, 25 South St., New York City. The advantages with such requirements are, for example, a direct-connected generator furnishing current for the lighting and elevators in an office building. The size of the generator and that of the engine are reduced by having high-speed, high-pressure and long-range cutoff, thereby reducing the floor space required and the first cost. Close regulation is necessary to avoid flickering of the lights due to fluctuation in load caused by the operating of elevators.

A brief description of the construction and operation of the dashpot follows: *A* represents the engine cylinder. When the dashot plunger is released and the air that is taken in through the air valve *C* is discharged through the check valve *D*, which is adjustable, the piston *B* will take the thrust noiselessly and without rebound, owing to the air cushion and to the slight yielding of the spring, shown in the chamber of *E*, which is not more than $\frac{1}{16}$ in. at the maximum. The spring is of a heavy, durable type, not subject to great changes, and should give no trouble. It is obvious that all the air cannot escape through the check valve *D* instantly, therefore a portion is compressed in the chamber of *E*, caused by the slight yielding of the spring. This air forms a cushion for reseating the movement of the piston *B*, and at the same time the air is given a period in which to escape, and disposing of the air under the piston means a particularly high vacuum or the maximum atmospheric pressure on the face of the plunger regardless of whether the lift is $\frac{1}{16}$ in. or to the maximum.

Should there be, by reason of poor adjustment, a slight space between the piston and the plunger, this is mechanically eliminated by having a type of valve gear with the clearance at *G* reduced to a minimum (about $\frac{1}{64}$ in.) This small amount of clearance is made possible by having a dashpot spring, which serves as a preventive against breaking any member of the valve gear. Therefore it is not necessary to make allowance for the expansion of the engine cylinder, for dirt or poor adjustment.

The conditions mentioned are favorably affected as follows: With a high speed with the long-range gear cutting off at the maximum, the period of cutoff is very short; this is accomplished by reducing the radius *H* to a minimum, thereby reducing the lift of the dashpot plunger, which means a shorter period required for complete cutoff. The long-range valve gear cutting off at the minimum, the lift of the plunger is slight; having the maximum atmospheric pressure on the face of the plunger regardless of the lift, the friction on the steam valves is overcome. The complete cutoff of the steam takes place more rapidly and positively regardless of the variation of the load on the engine, thereby avoiding leaky valves and poor regulation. It is evident that the positive seating of the vacuum-pot plunger will permit a smaller lap with the result that less angular advance is needed.



SECTION THROUGH DASHPOT

Therefore this means a greater range of cutoff under control of the governor and a corresponding increase in horsepower.

Instrument Voltage Transformers

By W. R. Woodward,

General Engineer, Westinghouse Electric & Mfg. Co.

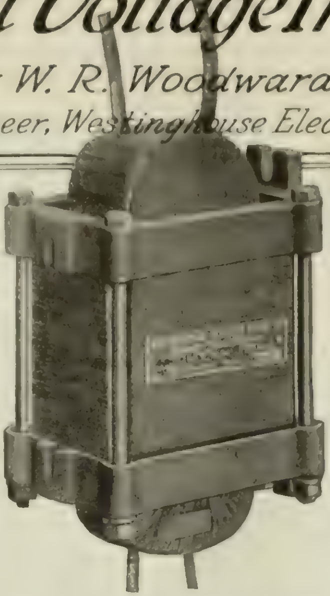


FIG. 1. DRY-TYPE TRANSFORMER

WHEN the line pressure is 250 volts and less, it is common practice to wind the voltage coil of the measuring instrument for line voltage. It is obviously not practical to wind and insulate instrument coils for voltages higher than 750 volts, so a voltage transformer is necessary to reduce the pressure to a lower value. The transformer thus serves as a safety barrier by keeping the high voltage away from the instrument and also makes it possible to standardize on instruments of a single voltage range. The voltage transformer is similar in construction and application to a small power or distribution transformer, its secondary load being the windings of the instruments or meters to which it is connected. The high-voltage winding is connected to the wires whose difference in potential it is desired to measure. This difference in potential, or voltage, causes a current to flow through the high-voltage winding. The amount of current that will flow depends on a number of factors, such as the value of the voltage, frequency, number of turns and quality of iron in the transformer. The current will be just sufficient to produce the proper magnetic flux in the transformer iron to generate a back, or reversal, voltage approximately equal to the applied voltage. This flux is, of course, pulsating or alternating the same as the applied voltage, and thereby generates or produces a voltage in any other winding that may surround the core. The value of the voltage so produced depends directly upon the relative number of turns with respect to the primary windings, so that the secondary voltage equals the primary voltage divided by ratio of primary to secondary turns. If the primary has 4000 turns and the secondary 200, their ratio is 20: 1 and the secondary voltage is one twentieth of the primary. The foregoing is not strictly correct, as in order to get greater accuracy a few primary turns are omitted to compensate or make up for the small losses in the transformer. This compensation is usually about one-half of one per cent. When the transformer is not connected to its secondary load, the secondary voltage is usually higher than its ratio indicates, but when carrying its proper load the ratio of primary to secondary voltage should be correct as marked on the nameplate.

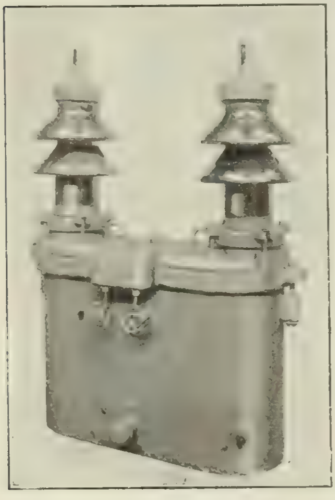


FIG. 2. OUTDOOR-TYPE 20,000-VOLT INSTRUMENT TRANSFORMER

Fig. 4 shows a cross-section through a typical voltage transformer. H_v is the high-voltage winding, well insulated from the iron magnetic circuit F and low-voltage winding L_v. Any flux set up by the magnetizing current flowing in the primary coil H_v will follow the iron circuit on account of the very high permeability of the iron, and will therefore pass through L_v the low-voltage coil also. This form of construction is commonly used for dry-type transformers for voltages up to 3000 or 4000. A voltage transformer of this type is shown in Fig. 1.

Fig. 5 gives a different arrangement of coils. This form is adapted for a higher voltage—from 5000 to 10,000 volts. It will be noticed from the figure that two high-voltage coils H_v and two low-voltage coils L_v are used. This type is usually mounted in an oil-filled tank, as in Figs. 2 and 3. Using two coils cuts down the voltage per coil and thereby makes it easier to insulate. For still higher voltages the core-type form shown in Fig. 6 is best adapted. The low-voltage winding is placed close to the core and insulation barriers, in the form of tubes, placed between it and the high-voltage coils. The high-voltage winding is broken up into a number of coils, as indicated, in order to keep the voltage stresses down. This type of construction is especially well adapted to voltages of 15,000 or 20,000 and up as high as voltage transformers are built. Fig. 2 shows an outdoor voltage transformer for use on a 20,000-volt circuit and Fig. 3 an outdoor-type of voltage transformer for

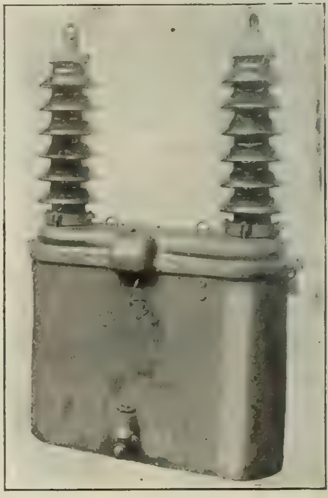


FIG. 3. OUTDOOR-TYPE 70,000-VOLT INSTRUMENT TRANSFORMER

70,000 volts. For the higher voltages a choke coil is sometimes connected between the transformer windings and the high-voltage leads. This coil is solely for protection against lightning and high-frequency disturbances. If a high-frequency surge comes down the line, when it tries to pass into the transformer it meets a very high impedance in the choke coils and is forced to pass down the line, where it can be safely conducted to ground by the protective apparatus. Of course a high voltage is built up across the choke coil, but it is specially insulated between turns for this condition, and even in case of failure between turns of the choke coil, the transformer will still operate without error. If the break were in the high-tension winding of the transformer, it would burn out immediately. The choke coil has no effect at normal frequencies, as its impedance varies directly with the frequency, therefore offers little opposition to the flow of current at normal frequency, but it offers great opposition to lightning disturbances of very high frequency.

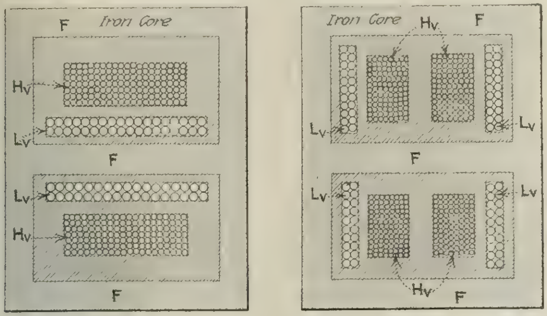


FIG. 4 FIG. 5

FIGS. 4 AND 5. SECTIONS THROUGH SHELL-TYPE TRANSFORMER

If the secondary terminals of a transformer are connected to an instrument or meter, a current will flow through the meter. This current flowing through the secondary winding tends to oppose the flux in the core or to demagnetize the core. This tendency is immediately counteracted by a current which will flow in the opposite direction through the primary winding. It is a fundamental law of the transformer that neglecting the exciting current, the primary current is equal to the secondary current divided by the ratio of primary to secondary turns; or another way of expressing it is to say that the primary and secondary ampere turns are equal but have opposite directions around the magnetic core.

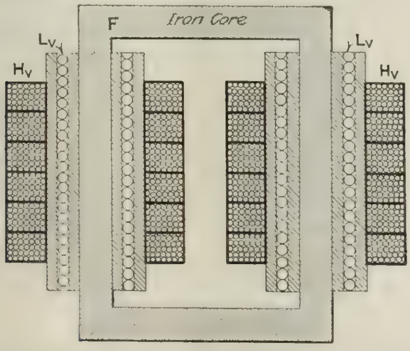


FIG. 6. SECTION THROUGH CORE-TYPE TRANSFORMER

In connecting instruments in which both current and potential are measured as in a wattmeter, a definite relation must be maintained between the current and potential. If either current or potential wires are reversed, the meter will not read correctly. For this reason it is necessary to know the relative direction of current in primary and secondary leads.

Referring to Fig. 7, the arrows show the relative direction of currents in the leads and windings. In tracing a lead on a diagram, the line *A* to *X* may be followed as indicated by the large arrow, just as though the transformer did not exist. In checking the actual wiring, however, it is necessary to know which two leads correspond to those marked *A* and *X* in the diagram. It is customary for the manufacturers to designate these two leads with a distinguishing mark such as white paint or tape. The marked leads bear the relation to each other as indicated for leads *A* and *X;* that is, "ingoing" current in the primary "marked" lead gives "outgoing" current in the secondary "marked" lead.

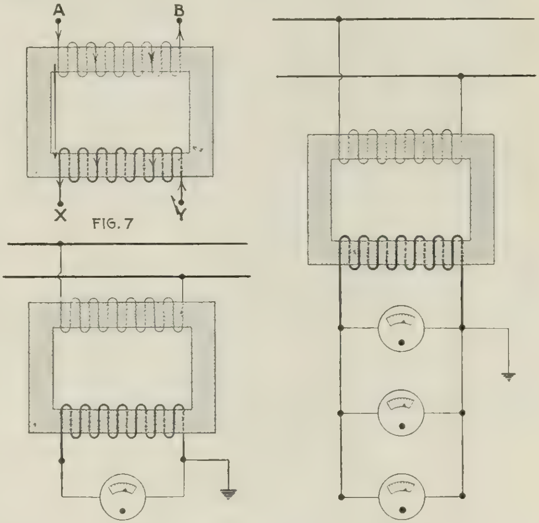


FIG. 7 FIG. 8 FIG. 9

FIGS. 7 TO 9. TRANSFORMER CONNECTIONS TO MEASURE VOLTAGE ON A SINGLE-PHASE CIRCUIT

Fig. 8 represents the connection of a transformer to a single-phase line and to a single instrument. If several instruments are to be connected to the one transformer, they are connected as shown in Fig. 9; that is, the instrument coils are all put in parallel across the secondary leads of the transformers. The total current flowing through the transformer secondary winding will be the sum of the currents flowing in all instruments so connected.

The most common connection on three-phase circuits is that of two transformers in open delta, Fig. 10, by which the voltage on all three phases may be measured. Since the transformer No. 1 is connected from *A* to *B*, meter *A* will measure to voltage between these two conductors. Transformer No. 2 is connected from *B* to *C*, consequently meter *B* will indicate the voltage between the two conductors. Meter *C* is connected across the secondaries of transformers Nos. 1 and 2; however, the relation between the voltage of these two transformers is such, when connected to a three-phase circuit, as in the figure, as to give the voltage between *A* and *C* divided by the transformer's ratio. Therefore, meter *C* will measure the voltage between conductors *A* and *C*, just as it would if connected to transformer No. 3. If the voltages are balanced on the high-voltage side, instruments *A*, *B* and *C* should read the same.

In case of three phase four-wire circuits it is common practice to connect the primary of the transformers from outside wires to neutral, and in order to measure all voltages, this requires three transformers connected in star on the high-tension side. It is usual practice to also connect the low-tension in star. The three-phase voltages between *X* and *Y*, *Y* and *Z* and *X* and *Z* are the same as between *A* and *B*, *B* and *C* and *A* and *C* except on a small scale. If it is desired to know the voltage from *A* to *B*, a meter placed across *X* and *Y* will give this value divided by ratio of turns of primary to secondary in the transformers. Also a reading from *X* to *O* will indicate the voltage from *A* to *N*, etc.

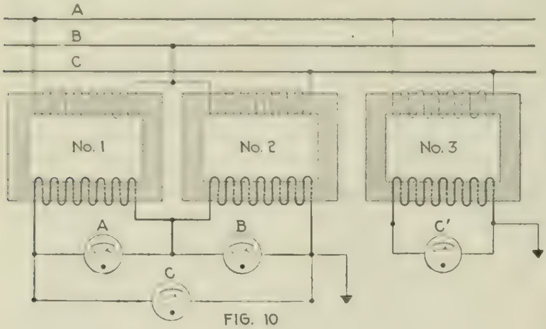


FIG. 10

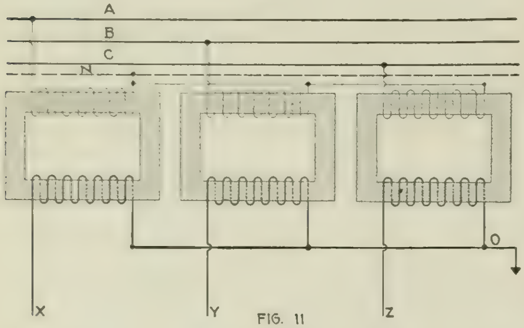


FIG. 11

FIGS. 10 AND 11. TRANSFORMER CONNECTIONS TO MEASURE VOLTAGE ON A 3-PHASE CIRCUIT

It will be seen that the secondaries of all the transformers are ground; in fact, every secondary network should be grounded. This serves to drain off any static charge the instrument may take due to condenser action of the primary and secondary windings. Also in case of failure of insulation between high-voltage and low-voltage windings, the high-tension current will flow to earth through this ground instead of through some other path, which might be from the winding of the instrument to its case and then through the attendant to ground. Either or both the instrument and attendant might thereby be injured. As a safety-first rule the secondary circuit should always be well grounded.

An oil well has been defined as a hole in the ground, a quarter of a mile deep, into which a man may put a small fortune or out of which he may take a big one—he never knows which until the hole is finished.

Trouble with Scored Fuel-Valve Seat

By D. L. Fagnan

Melting out of exhaust valves at heavy load and a smoky exhaust causing complaints from a near-by hotel and business block were the conditions that demanded the services of a troubleman versed in the ways of Diesel engines, and it was my luck to draw the job. Conversation with the engineer brought out the fact that there had been a smoky exhaust on this engine ever since he had taken the position and that the fuel nozzles and all valves needed considerably more grinding in than any other Diesel he had ever operated. He said that the pressures carried were higher than was good practice because the engine seemed to require such pressures for good running, but he never could obtain a clean exhaust. These facts gave me a clue as to where to look for the trouble.

The engine used too much fuel per kilowatt-hour, as shown by the notes and record of the plant. Within perhaps one week of operation after an overhauling the atomizers would stop up with carbon, the fuel nozzles would stick open, and before the load could be transferred to one of the other engines, a large hole would be found burnt through the exhaust valve, causing havoc generally. The engineer had tried nearly every means to locate and remedy the trouble and put the problem up to me.

Many articles relating to Diesel-engine troubles and their remedies appearing in the mechanical papers had come to my notice. My memory informed me that a somewhat similar case had been recorded, but my back copies were destroyed and there was no way of finding out the paper in which it had appeared. However, I knew the trouble had been found in the fuel nozzles and so these claimed my attention. The fuel needles were carefully examined and found to need slight regrinding. The seats were hard to examine as they were deep in pockets; so a soft-pine stick was cut to about the same shape as the fuel nozzle, and the ends were sandpapered true and smooth. By striking this stick repeatedly but lightly with a hammer, a good impression of the nozzle seat was obtained. By the use of this device, two small grooves were found in one seat and three in another, the third being in good condition.

The engineer said that No. 2 cylinder had given no trouble from burnt exhaust valves, but that Nos. 1 and 3 had caused all the mischief. It was the nozzle seat on No. 2 cylinder that was not scored or grooved. About fifty miles from this plant an erecting man from a different company was installing Diesel engines, and I rushed there to see whether a reamer could be obtained, taking a fuel nozzle with me. Luckily, they had a reamer which had been obtained from the shop for just such a job. This was borrowed and used to good advantage. The fuel needles were ground in, and on testing out the seats were found to be perfect. When the engine was started up, the exhaust was clear and no further difficulty was experienced. A reamer was ordered sent from the factory for future emergencies of like nature, but so far no use has been found for it.

It would be hard to guess how this fault would have been located if it had not been for my reading about some engineer overcoming just such a trouble. His sending his experience to a technical journal proved a blessing, for this is such an unusual trouble that one could be excused if he did not find it.

Overcoming Blow-off Valve Troubles

BY PHILIP ECKENROTH

IF THE service conditions of blowoff valves were analyzed, it would be found that the most serious element is the accumulation of scale against the seating surfaces when the valve is shut, as shown by Fig. 1. This deposit is pressed firmly against the seating surfaces of the plugs or moving members and has the effect of a stick of emery with the boiler pressure as a lever pressing against it. And the harder the scale and the more the valve or cock is operated, the quicker the surfaces are destroyed.

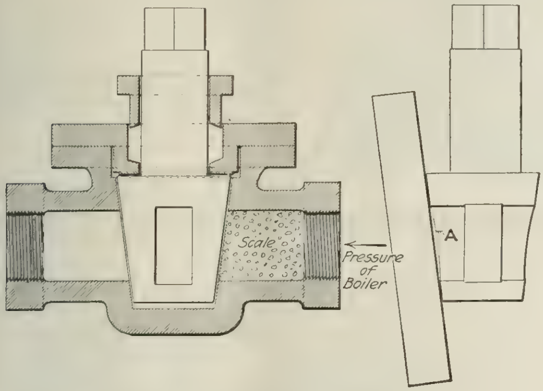


FIG. 1. PLUG COCK SHOWING BANKED SCALE AND WORN PLUG

If a straight-edge is placed on a badly worn plug, one can see between the plug and the straight-edge at about the opening through the cock, as at *A*. The same effects are produced where surfaces are moved with the scale bearing against surfaces, as in gate valves, etc.

This causes the valves to score in the direction of their line of travel and produces leaks in a short time. Therefore, in order to prevent leaks it will be necessary to arrange the seating surfaces of plug cocks or plungers of seatless valves so that the scale will not be pressed against them, as no means are provided for taking care of this wear.

Blowoff service is regarded as the hardest to which a valve or cock can be subjected, and after an experience of over 25 years as a repairman of such, and after trying about every valve and cock on the market and watching the results of other engineers, I came to the conclusion that to obtain good service from such valves it would be necessary to design one that could use the scale and mud as a medium for keeping the seating surfaces in shape.

This might at first look like a hard proposition, but it proved simple after a little experimenting, although it required a complete change in valve design and operation in order to have a better valve after two years of use than at the start so far as the seating surfaces were concerned.

In order to obtain this result it is necessary to have a close-grained cast-iron disk with a bronze or monel-metal seat; a rotation of the disk on the seat after it comes in contact with the seat; seating surfaces held together by a resilient means during the operation of closing the valve, using the scale and mud to keep valve seats in shape. The results of this combination are surfaces that can be matched only by a grinding machine operation. When one can produce better seating surfaces in a valve after two years' use than when it was new by the simple means of opening and closing it, that is a valve that will stay on the job as long as there is a piece of the disk or seat left.

Such a design of valve is used with boilers that are operated 24 hours daily, 300 days a year.

This valve, shown in Fig. 2, differs from others in that it has a floating yoke *A* separated about $\frac{1}{8}$ in. from the washers *B* by means of springs. The valve stem *C* has a square end that fits into a square hole in the disk *D* and is held in place by the nut *E*.

When the stem *C* is turned, the disk *D* turns with it, and when closing the valve after the disk *D* comes in contact with the seat *P*, it continues to rotate until the floating yoke *A* comes in contact with the washers *B*. Then the springs cease to be of any value and are virtually out of service, thus practically making a solid construction of the yoke and yoke studs. Moving the lever *G* in the reverse direction to the motion of the handwheel gives a firm seating and also acts as a lock and prevents any movement of the handwheel until it is released by the lever. The lever *G* can be used for reseating the valve while in service if necessary.

If the handwheel is screwed down until the disk *D* comes in contact with the seat *P*, using a little pressure to keep the seating surfaces together with the aid of the springs interposed between the yoke *A* and the washers *B*, and throwing pawl *H* up until it comes in contact with one of the spokes of the handwheel, the disk can be rotated on its seat while the valves are in operation. In this way the valves can be kept in service as long as there is a piece of the disk and seat left.

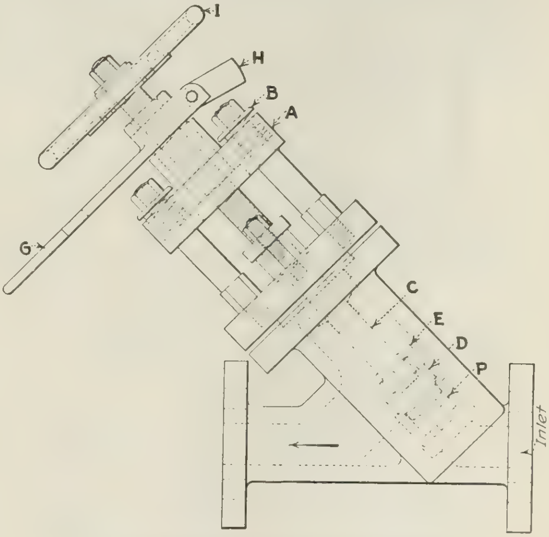
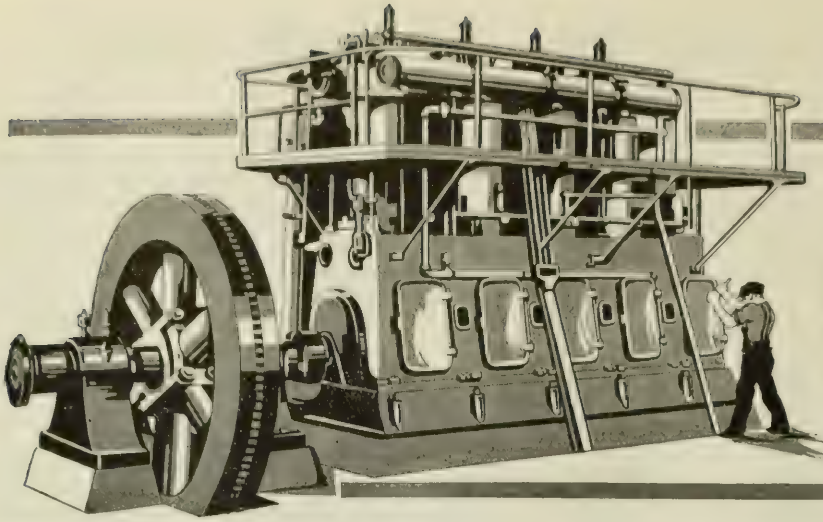


FIG. 2. DETAILS OF THE BLOWOFF VALVE

This means years of use without leaks and repairs, and this valve has made a hard problem easy. It is patented but it is not for sale. We make it for our own use.



Talks on DIESEL Engines

by L. H. Morrison

XIII—*Governors and governor troubles form the subject of the chief's talk, after he announces the cheering news of a general increase of pay.*

THERE was air of lightness and cheerfulness in Egan's manner as he came into the engine room, and so the men rightly suspected that he had something of unusual interest to tell.

"It has always riled me that the men in the turbine plant drew more money than we did, because I felt that our cost per kilowatt-hour was low. Last week I had a chance to compare the Diesel and the turbine costs, and ours were a shade lower, and ever since I've been working for a raise. While I was at supper the supervisor 'phoned and told me we'd all been given a raise of five iron men a week."

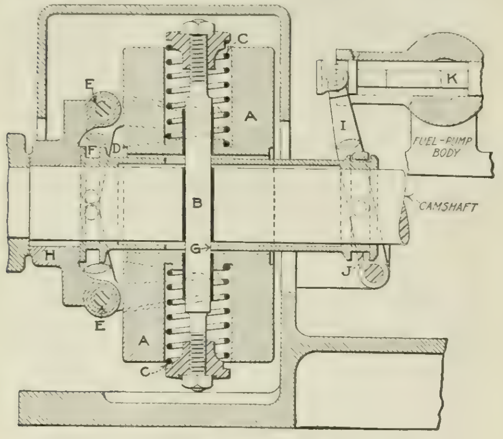


FIG. 1. GOVERNOR OF McEWEN ENGINE

The buzz that followed this announcement just escaped being a cheer. While it was subsiding, Egan opened his desk, took out his sketches for the evening's talk, and seated himself at the table.

"After discussing fuel pumps," he said, "the next detail that would naturally follow is governors. This sketch, Fig. 1, shows a cross-section of the McEwen engine governor. Two weights *A* are held together by the spring bolt *B*, which passes through the camshaft. When the camshaft rotates, the weights are moved outward by centrifugal force against the resistance of the springs *C*. Each weight is connected to one arm of a bell-crank lever *D* pivoted at *E* and the other arm of the lever carries a pin that fits in a groove *F* in the loose sleeve *G*. The collar *H* carrying the pins *E* is keyed to the camshaft. When the engine speed rises, the outward movement of the weights is transmitted to the bell cranks and moves the sleeve to the right. The lever *I*, which has a pin fitting in the groove *J*, is thus swung to the right, moving the wedge *K*, which

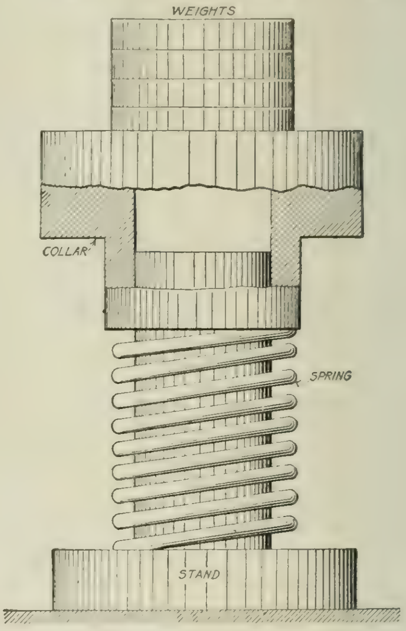


FIG. 2. STAND FOR TESTING GOVERNOR SPRINGS

In the next article the subject of the chief's talk will be the supplying of high pressure air for the injection of the fuel charges

shortens the suction stroke of the fuel pump. This type of governor is ideal for small engines. It is simple, easily adjusted and has few pivots, so there is little lost motion due to pivot wear. However, it's practically impossible to get the two governor springs alike. The result then is that one weight will move out farther than the other, causing binding between the governor weight levers and the sliding sleeve."

"Well, chief," the ever-inquisitive Woods asked, "how can you judge if the springs are alike?"

"In the ordinary plant it's not easy to do, but you can get a fair idea by turning up an iron or brass stand and collar, such as this (Fig. 2)," Egan said, rapidly outlining his idea. "Then by placing weights on the collar or table and measuring the deflection of the springs at various loads, any great difference will show up. It's surprising how springs will vary. If I had my way, all the valve springs on an engine would be made from the same bar of spring stock. Then I'd insist that all must be hardened at exactly the same temperature. I've heard many an engine damned because of too weak or too strong governor and valve springs.

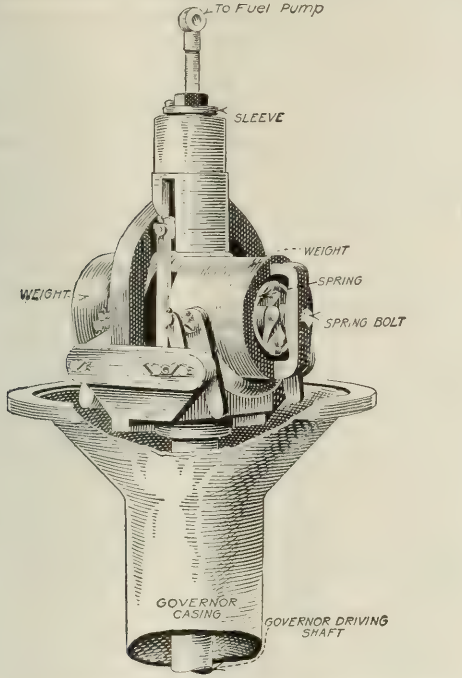


FIG. 3. GOVERNOR OF ALLIS-CHALMERS ENGINE

"But that's enough of springs. Now let's take up Fig. 3, which shows the governor used on the Allis-Chalmers engine. It has only one spring between the two weights, is very accurate in governing and has no more wearing parts than a good design demands. One very desirable feature is that it revolves at considerably above engine speed, which allows lighter governor weights to be used than if run at the speed of the engine. Of course, the lighter the weights the less the wear at the pivots.

"It's generally conceded that a governor should be well lubricated, but it has been difficult to do this without having the oil thrown off by the revolving parts. This has been prevented in this design by inclosing the governor in an iron case. The lubricating oil enters the top and the entire mechanism is in a bath of oil.

"The next governor that I've thought worth our while is the Jahns, which, with modifications to suit it to the particular engine, is used by the National Transit Co., the Busch-Sulzer Diesel Engine Co. and the Snow Co. In the National and Snow engines the sliding collar is below the governor, while in the Busch engine it is above the governor. This modification has no effect on the working, being merely a convenience in attaching the fuel-pump mechanism.

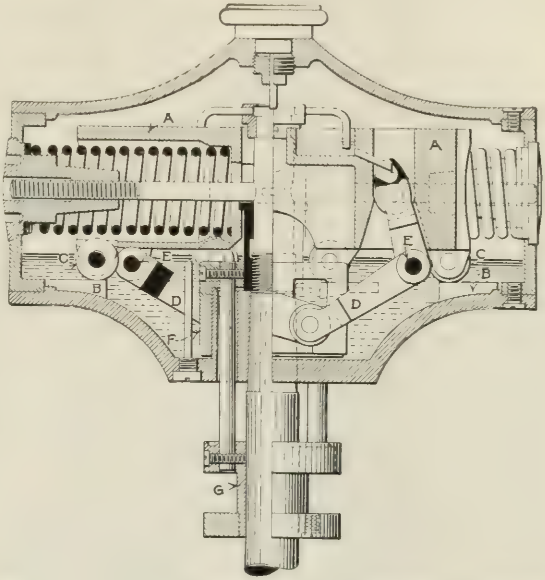


FIG. 4. JAHNS GOVERNOR USED ON NATIONAL ENGINE

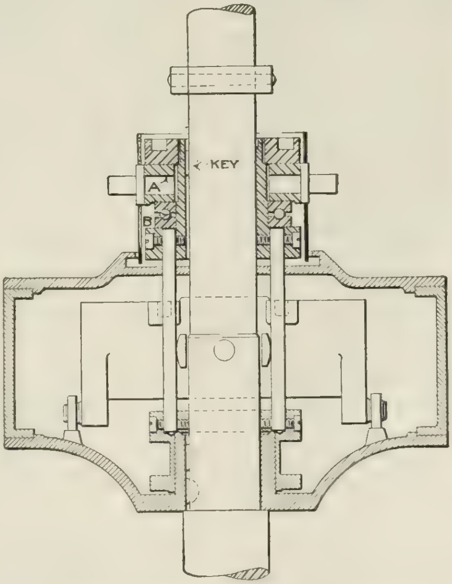


FIG. 5. JAHNS GOVERNOR USED ON BUSCH-SULZER ENGINE

"Fig. 4 shows a sectional view of the Jahns governor used on the National engine. It governs the fuel charge by controlling the time of closing of the suction valve. One of its most admirable features is the use of a speed regulator."

"What changes of speed can you get?" Kelly inquired.

"With this type of regulator, a variation of 5 per cent. up and down from normal."

"Then I can't see much good in it," Kelly declared.

"You are wrong there, Kelly. Only a small speed variation is wanted. In a flour-mill drive it's highly desirable to give the lineshaft the proper speed, but the variation won't be over 3 per cent. Take our power plant here. When we run in parallel, if our engine speeds are not the same, the fast one will pull enough of the load to bring its speed down to the other. This means one unit is loaded while the other is comparatively idle, and so we need a regulator to split up the load. It isn't often that a correction of more than 5 per cent. is necessary. The striking feature of the Jahns governor is that the weights *A* do not swing on pivoted arms but move in and out on tracks *B*, guided by rollers *C*. The bell-crank lever *D*, pivoted on the pin *E*, carries at the ends of its arms two rollers, one of which fits in a groove in the weight *A* and the other in a groove in the sleeve *F*. Thus, any radial movement of the weights causes a vertical movement of the sleeve, which is then, in turn, communicated to the fuel-pump mechanism through the external collar *G*. The entire governor mechanism operates in an oil bath, there are few pins or parts to wear and the regulation is excellent." "Now, chief," broke in Kelly, who thought he had trapped Egan, "you kicked about a governor with two springs, because they weren't exactly alike. Yet here you are boosting that same kind of a governor." J. R. laughed good naturedly and proceeded to explain.

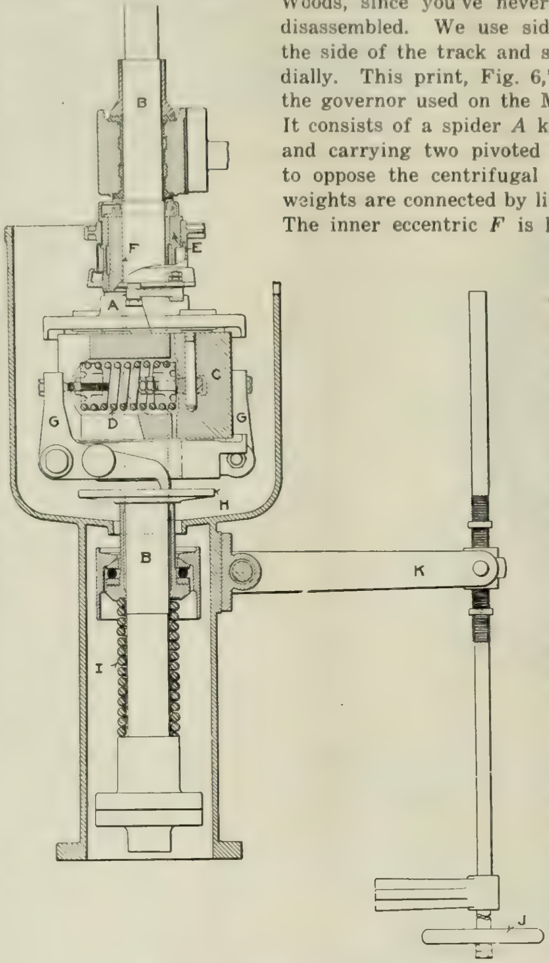


FIG. 6. GOVERNOR OF McINTOSH & SEYMOUR ENGINE

"If you'll remember, my remarks referred to a governor in which the weights are connected together and control the sleeve by a system of pivoted links, so that the two springs really act on both weights. In the Jahns governor each weight acts on its own spring, and as the linkage is not rigid there may be some slight difference between the springs without affecting the regulating qualities of the governor. The Jahns governor adapted for use on the Busch-Sulzer engine is shown in Fig. 5. In this case the sliding collar *A* is above the governor instead of below, to simplify the connection to the fuel pump. Ball bearings *B* on the sleeve prevent binding and eliminate friction, and as a result the governor is very sensitive. There is one point to be emphasized and it applies to all other governors—keep the governor parts scrupulously clean. Don't let grit accumulate, and the governor's life will be doubled."

"Chief," said Woods, seeing that Egan was through with this governor, "what keeps the two weights from jumping the track? When they revolve, I'd think they would hang back, and the rollers slide off the runway."

"That's a reasonable question for you to ask, Woods, since you've never seen our Jahns governors disassembled. We use side rollers that bear against the side of the track and so make the weights run radially. This print, Fig. 6," continued Egan, "outlines the governor used on the McIntosh & Seymour engine. It consists of a spider *A* keyed to the vertical shaft *B* and carrying two pivoted weights *C*, with springs *D* to oppose the centrifugal force of the weights. The weights are connected by links to the outer eccentric *E*. The inner eccentric *F* is keyed to the shaft, and the outer one moves around it when shifted by the governor. To secure speed regulation, the outer end of each spring is held by a regulator lever *G* whose other end rests on a flat collar *H*. The thrust of the levers is opposed by the spring *I*, and to make a change in the speed, the handwheel *J* is turned, moving the lever *K* and so changing the tension of the springs *D* by moving the flat collar *H*." "Why are the weights made so heavy?" Woods asked. "To overcome the resistance. Remember that the fuel-pump plunger is driven from the governor eccentric. If the plunger is $\frac{5}{8}$ in. in diameter and the injection air pressure is 1000 lb. per sq.in., the governor will have a resistance of about 350 lb. to overcome, and so the weights must be heavy. This feature doesn't seem to be objectionable, for the governor handles a variable load in fine shape. The weight of the flywheel has a lot to do with the closeness of regulation of a governor. The flywheel must be heavy enough to take care of any speed variation during a single cycle, for the governor cannot act between two successive power impulses. If the flywheel is too light, it will not be able to absorb the excess energy between explosion and the following compression, and if the governor attempts to control the fluctuations, hunting will result. If the flywheel is too heavy, and the load comes on suddenly, the inertia of the wheel will prevent a rapid change of speed and the decrease of

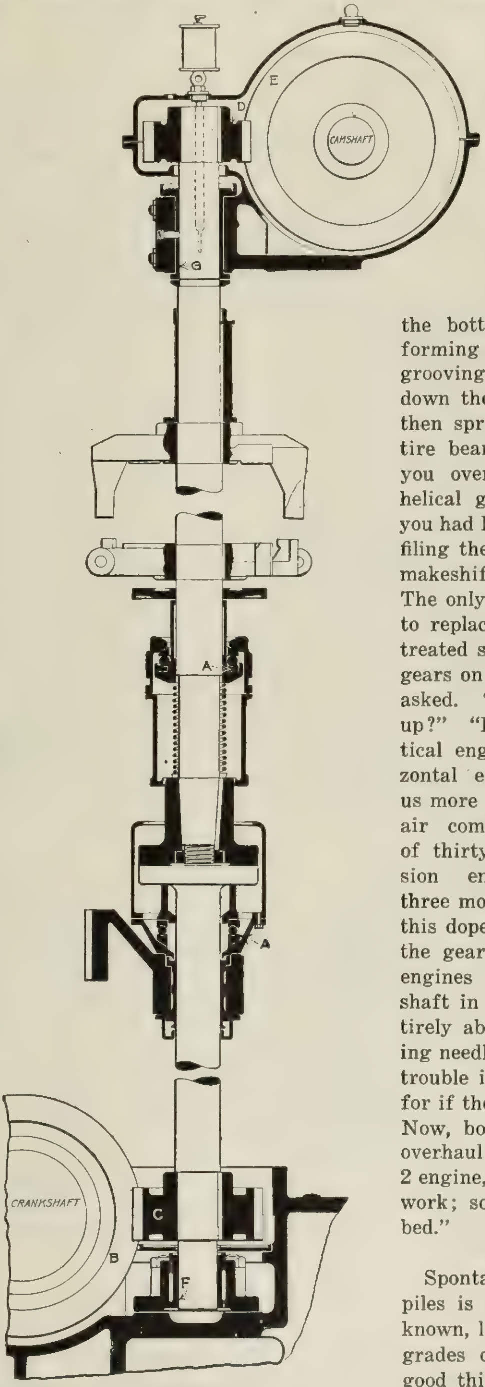


FIG. 7. GOVERNOR DRIVE-SHAFT ARRANGEMENT

engine speed will be very slow. If there is much internal resistance, the governor will act slowly and allow the engine speed to die down considerably before the fuel charge is increased. At this point the inertia of the flywheel will be so great as to prevent the engine speed from returning at once to normal. So, you see, with a varying load a flywheel can be too heavy as well as too light. This is a matter for the designer rather than the operator, but poor calculation of flywheel weights has condemned more than one perfectly good engine." "Why is it that we've had so much trouble with the governor drive shaft?" Kelly wanted to know. "Well, let's look into it," said Egan. "Fig. 7 shows the governor drive shaft of a well-known engine, the weight of the governor and the shaft being carried by the ball-thrust bearing *A*. At the bottom the shaft is driven from the crankshaft through the helical gears *B* and *C*, and at the top the helical gear *D* drives a similar gear *E* on the camshaft. The pressure exerted between the teeth of the helical gears causes a downward thrust that is added to the weight of the governor and shaft. If the balls or the race of the bearing *A* wears, the shaft will be lowered by the amount of the wear, throwing the thrust on the teeth of the gears and causing rapid wear. It's true, as the manufacturer's representative said, that the ball bearing should be attended to; but it's incased and can't be seen in operation. It doesn't take but a few minutes, after a ball breaks or a ball race cuts, until the gears are screeching and cutting. This, Kelly, has been the big part of our trouble. The bronze bearing *F* at the base of the vertical shaft, gives some trouble by wearing. It merely acts as a guide for the shaft; but its oil supply easily chokes if it warms up, and the result is a ruined bearing. I would say that an extra bearing is a mighty good thing to keep around. It doesn't cost much and means only a short stop instead of a long wait to secure one from the builder." "Well, how about the upper bearing?" demanded Kelly. "The cause of wear at this point is due to the tendency of the two gears *D* and *E* to push apart. It happens that the vertical shaft bearing *G* is weaker than the opposing bearing on the camshaft, and so the upper bearing wears. If it wears the slightest amount, the gear has a tendency to climb, throwing still more pressure on the bearing. I think it wouldn't wear much if the oil grooves were properly made. At least, the last time we replaced this bearing, I cut the grooves only half way down the bore, and that seems to have stopped our trouble. Evidently, when the grooves extend the full length, the oil flows to the bottom of the bearing without forming a film around the shaft. By grooving the bearing only part way down the oil flows to the bottom and then spreads out, lubricating the entire bearing." "Mr. Egan, how can you overcome the trouble with the helical gears wearing? I've noticed you had Kelly filing the teeth." "Kelly's filing the teeth was only a temporary makeshift to smooth up the surfaces. The only hundred per cent. remedy is to replace the bronze gears with oil-treated steel gears." "How about the gears on a horizontal engine?" Kelly asked. "Do the same troubles show up?" "Before we ever put in a vertical engine, we had a 300-hp. horizontal engine. The gears troubled us more than anything else except the air compressor. I kept a record of thirty-one different high-compression engines by writing every three months to the engineers. From this dope it appears that trouble with the gears and layshaft in horizontal engines and with the vertical drive shaft in vertical engines is never entirely absent. Cleaning and regrinding needle valves is expected, but gear trouble is not natural and is uncalled for if the gears are designed properly. Now, boys, tomorrow we've got to overhaul the air compressor of the No. 2 engine, and that means a lot of hard work; so we'd better quit and go to bed."

Spontaneous combustion of coal in piles is common and it is, as is well known, likely to occur with the poorer grades of bituminous coal. It is a good thing to remember, in this connection, that coal should not be piled to a height greater than twelve feet, and that when spontaneous combustion does occur, water has but little effect in putting it out. To prevent coal piles from taking fire, the coal should be turned over when undue heating is apparent.

The Electrical Study Course—Inductance and Resistance on Three-Wire Generator

Presents the customary arrangement of the armature connections and the inductances used for a three-wire generator. Also deals with the direction of flow of current through the inductances for conditions of unbalanced load.

IN THE preceding lesson it was stated that both direct and alternating currents can flow through the same conductor at the same time, and that by making use of this fact and having the conductor in the form of an inductance, it is possible to restrict the flow of the alternating current to very small values, while permitting free passage to the flow of the direct current. We shall now investigate how such an arrangement applied to a three-wire generator will provide a three-wire system of distribution, and do it as economncally as would a balancer set in conjunction with a plain two-wire generator.

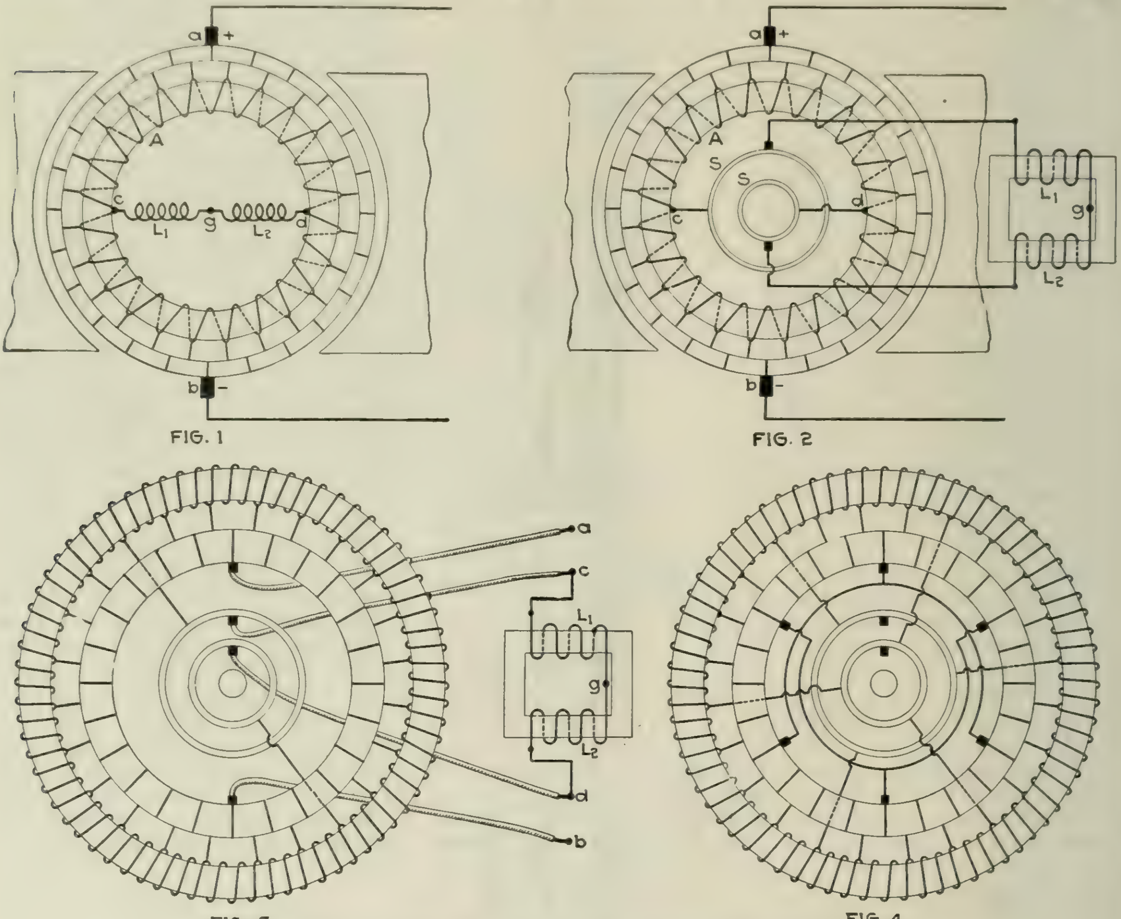


FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIGS. 1 TO 4. SCHEMATIC DIAGRAM OF THREE-WIRE GENERATORS

In the discussion leading up to the presence of alternating current in the inductances connected to opposite taps of the armature winding of the generator, the inductances were considered as revolving with the armature, as illustrated in Fig. 1, in which *A* represents the armature winding, *a* and *b* the brushes on the commutator for the direct current, and *c* and *d* the points at which the inductances L_1 and L_2 are connected to the armature winding. It was shown that with such an arrangement the voltage from *a* to *g* is the same as that from *g* to *b*, irrespective of what part of its revolution the armature is in. As a matter of fact, the inductances do not have to revolve with the armature and generally in practice they are made stationary, contact being made with the points *c* and *d* through slip rings and brushes, as illustrated in Fig. 2, in which *SS* represents the slip rings that revolve with the armature *A*. The inductance is usually made up in the form of laminated square iron loop with a coil wound on each of two parallel legs, as shown in Fig. 2. The neutral is connected at point *g* between the two coils. On account of the easy path offered to the flow of magnetism in the iron core, a very small alternating current flowing in windings L_1 and L_2 set up a magnetic field sufficient to produce a counter-voltage in the coils almost equal to the alternating voltage applied to them, consequently keeping the current down to a very small value. Assume that the resistance of the two coils L_1 and L_2 in series is 0.2 ohm; if the coils were connected to 220 volts direct current, the amperes would equal $\frac{E}{R} = \frac{220}{0.2} = 1100$. On the other hand, when alternating current attempts to flow in the coils, owing to the changing value of the magnetic field there is a counter-voltage developed in the winding similar to the counter-voltage generated in the armature of a direct-current motor. Assume that the difference between the applied alternating voltage and the counter-voltage is one volt, which is not very far from what we might expect to find in practice; that is, the applied voltage is one volt higher than the counter-voltage This leaves only one volt effective to cause the current to flow through the resistance of the inductances, or the current in this case will equal $1 \div 0.2 = 5$ amperes. This 5 amperes may be considered as the current required to set up the magnetic field.

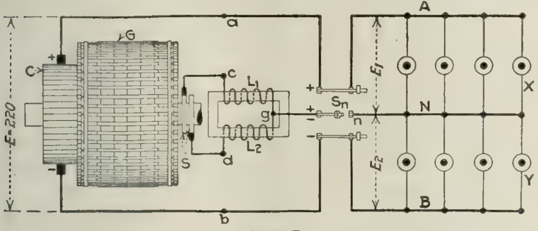


FIG. 5

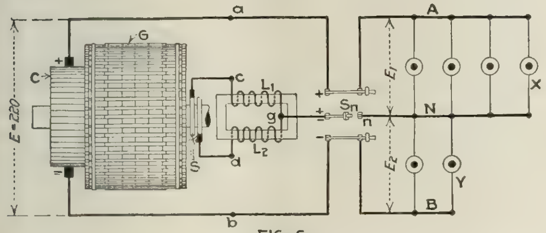


FIG. 6

FIGS. 5 AND 6. THREE-WIRE GENERATORS USING INDUCTANCE CONNECTED TO A LOAD

In Fig. 3 are shown the connections as they would actually exist in a ring armature, which has been chosen because of the simplicity of representation. In practice a drum-type armature is of course used, and there may be any number of pairs of poles, instead of only one as is the case for the armature shown. If more than one pair of poles are used, there would have to be as many taps to each slip ring as there are pairs of poles, and of course also as many direct-current brushes. In a six-pole machine, for example, the arrangement would be similar to that in Fig. 4.

The arrangement illustrated in Fig. 3 may be more simply shown as in Fig. 5, where *G* represents the armature, *C* the commutator and *S* the slip rings. These latter are connected to the inductances L_1 and L_2. The figure further represents the manner in which connections would be made to a three-wire service. As indicated, *a* and *b* are connected to the outside wires *A* and *B*, and the mid-point *g* of the inductances is connected to the neutral *N*. The functioning of such an arrangement will be made clear in what follows. If the load is exactly balanced as in Fig. 5, E_1 and E_2 will have the same value in this case, $\frac{1}{2} \times 220 = 110$ volts. Now it will be remembered that the voltage from *a* to *g* and from *g* to *b* is also half the voltage across *ab* and therefore likewise 110 volts. Consequently, the point *n* is at the same potential as the point *g*, and if switch S_n were to be closed no current would flow through it one way or the other.

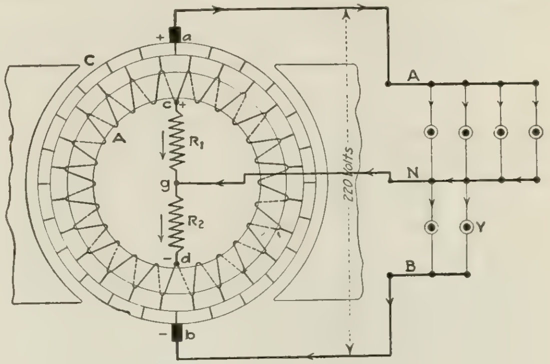


FIG. 7

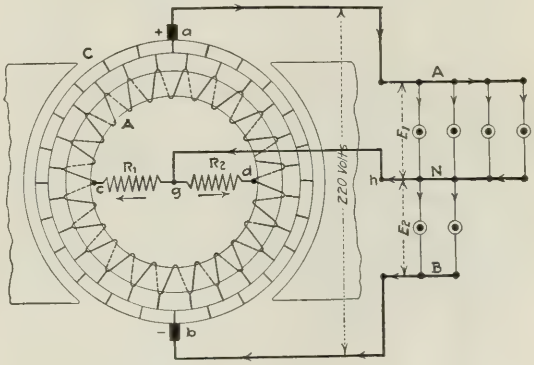


FIG. 8

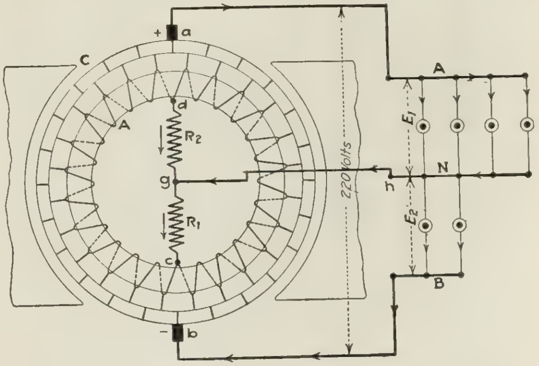


FIG. 9

FIGS. 7 TO 9. THREE-WIRE GENERATORS USING RESISTANCE CONNECTED TO A LOAD

Assume now, that the load is unbalanced as in Fig. 6, there being more lamps across *AN* than across *NB*. Then, as explained in the previous lessons, E_1 will be less than 110 volts and E_2 more. Since the largest part of the load is on the positive side of the system, the current would flow from *n* to *g* through L_1 and L_2 to the slip rings and back through the armature winding to the brush *a*, if the switch S_n were closed.

A fundamental difference between plain resistances and the inductances L_1 and L_2 is to be noted here.

Suppose the inductances to be replaced by resistances of 0.1 ohm each and their position of some particular instant to be that shown in Fig. 7. The current flowing through them, if there were no external load on the generator, would be equal to their combined resistance divided into the terminal voltage, or $\frac{220}{2 \times 0.1} = 1100$ amperes. Assume that load is placed on the system such that the resistance of X is 1.0 ohm and that of Y 1.25 ohms. Then the total resistance R_a across ag will be the combined resistance of R_1 and R_x in multiple, where R_x represents the resistance of load X; hence $R_a = \frac{1}{\frac{1}{R_1} + \frac{1}{R_x}} = \frac{1}{\frac{1}{0.1} + \frac{1}{1.0}} = 0.09091$ ohm. Similarly, the resistance R_b across gb would be found from the relation $R_b = \frac{1}{\frac{1}{R_2} + \frac{1}{R_y}} = \frac{1}{\frac{1}{0.1} + \frac{1}{1.25}} = 0.09259$ ohm. The total resistance across ab is equal to $R_a + R_b = 0.09091 + 0.09259 = 0.1835$ ohm, and the total current delivered by the generator would be $\frac{220}{0.1835} = 1199$ amperes. The voltage E_1 across ag is equal to the resistance R_a times the total current, or $0.09091 \times 1199 = 109$ volts, and the voltage E_2 across gb would therefore be $220 - 109 = 111$ volts. The current taken by R_1 would equal its resistance divided into the voltage across ag, or $\frac{109}{0.1} = 1090$ amperes, making the current through X equal to 1199 — 1090, or 109 amperes. Similarly, the current taken by R_2 would be $\frac{111}{0.1} = 1110$ amperes, and that through Y would be $1199 - 1110 = 89$ amperes. Now the difference between the current in X and Y is $109 - 89 = 20$ amperes, which flows through the neutral N and through R_2 to the armature winding in the direction of the arrowheads.

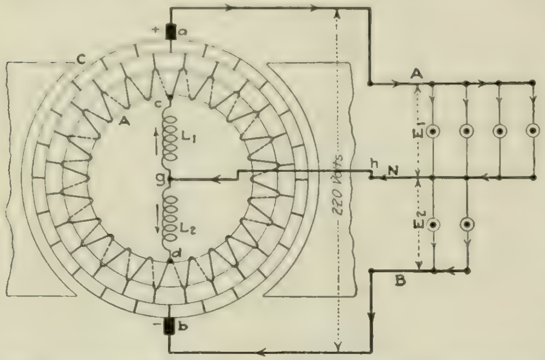


FIG. 10. THREE-WIRE GENERATOR SHOWING DIRECTION OF CURRENT IN THE INDUCTANCE

This increases the current through R_2, therefore the current through R_1 will have to decrease in proportion to the current increase through R_2, and we find this to be the case, since the former has a value of 1090 amperes and the latter 1110 amperes. The current through R_1 and R_2, it has been shown, would be 1100 amperes if there were no external load, hence under the conditions of load assumed, the current through R_1 has increased from 1100 to 1110 amperes, or 10 amperes. Thus, the decrease in one is equal to the increase in the other and each is half of the neutral current; namely, 20 amperes. This is the condition when the armature is in the position shown. When the armature has made one-quarter revolution, as in Fig. 8, the voltage across cd is zero; however, as explained in previous lessons, there is 110 volts from a to g and from g to b, consequently the neutral current will divide equally, 10 amperes flowing through R_1 and section ac of the armature and 10 amperes flowing through R_2 and section ad of the armature. When the armature has completed another quarter of a revolution, as in Fig. 9, R_1 is then carrying all the neutral current just as R_2 was in Fig. 7.

When the resistances are replaced by inductances, the same condition holds true except unless the unbalancing is very small, the neutral current divides equally between the inductances L_1 and L_2 at all parts of the revolution, and we will actually have a current flowing from g to c through L_1 and from g to d through L_2, as in Fig. 10; that is, one will flow up and the other down as indicated by the arrows, whereas in the case of the resistances of Fig. 7 the currents in R_1 and R_2 would have the same direction and would differ only in value. How the neutral current will divide and flow in opposite directions through the inductances will be made the subject of the next lesson.

The problem of the preceding lesson concerned a generator that supplies power to a two-wire system, the load on which consists of 500 fifty-watt 110-volt lamps, situated 200 ft. from the generator. It was required to find the capacity that the generator must have, the size conductor required for the line if rubber-covered wire is used, and the amount the generator must be overcompounded at full load to maintain constant voltage at the lamps. The total load is equal to the power required by each lamp times the number of lamps used, or, if W represent the load, we have $W = 50 \times 500 = 25{,}000$ watts. The current required to be delivered by the generator would be the number of watts in the load divided by the voltage, or $\frac{25{,}000}{110}$, which gives 227 amperes. Upon consulting the table of carrying capacities, we find that a No. 0000 wire would be required if rubber insulation is used. If the voltage at the lamps is to be the same at full load as at no load, it follows that the voltage at the generator must rise by the amount of the voltage drop in the line. The voltage drop in the line is equal to the current flowing in it times its resistance. The current is 227 amperes, as computed, and the resistance can be determined by looking up the resistance of No.

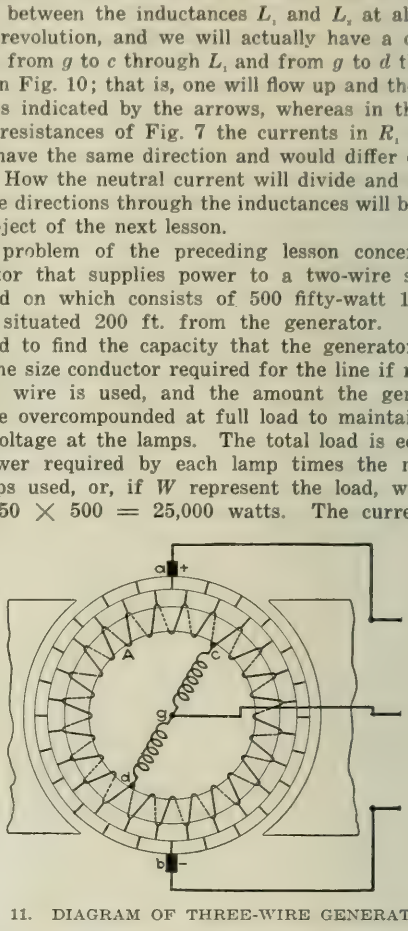


FIG. 11. DIAGRAM OF THREE-WIRE GENERATOR

0000 wire per foot, and multiplying by the length of wire in the line. Since the line is 200 ft. long and consists of two wires, the total length of wire is 2 × 200 ft., or 400 ft. From the table of resistances we find that No. 0000 wire has a resistance of 0.05023 ohm per thousand feet, making its resistance per foot $\frac{0.05023}{1000}$ or 0.00005023 ohm, and the resistance of the line $400 \times 0.00005023 = 0.02009$ ohm. From this we have that the voltage drop in the line is $227 \times 0.02009 = 4.56$ volts, which is the number of volts the generator must be overcompounded to maintain 110 volts at the lamps when they are all turned on.

In Fig. 11 the voltage across ab is 220 volts. At the instant represented, the voltage across cd is 190 volts. What is the voltage across ac and db? Is c positive or negative with reference to d? Is c positive or negative with reference to a? Is d positive or negative with reference to b? What is the voltage between a and g, and between g and b? Is g positive or negative with respect to a and b? Does the position of the armature have any effect upon the voltage relations of a, g and b?

Safety Platform at Coal Scales

A Middle-Western central station has embodied a safety feature in a new track-hopper house just constructed. This house stands over the double-track scales installed over the track hopper. It is large enough to accommodate two railroad cars standing side by side.

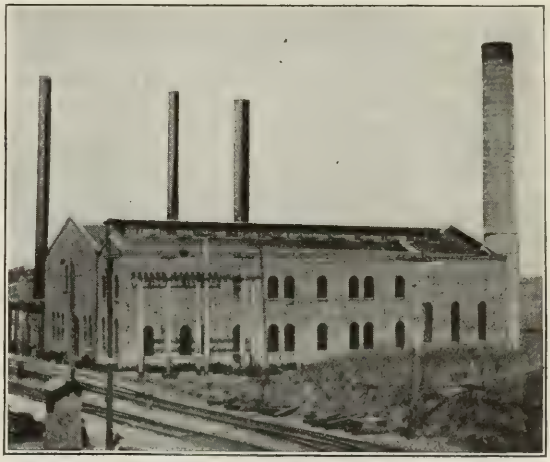
When coal is being dumped into the hoppers in such a house, it is the usual practice for men to stand on the edges of the cars to "bar down" the coal that may stick in the car. This trouble is especially bad in cold weather, when the coal may freeze in the cars. Men engaged in such labor are required to exercise considerable skill in balancing themselves on the edges of the cars lest they fall or be forced to jump to the ground or into the car. Accidents sometimes result from such falls. To relieve this condition the company has built a runway around the walls of the house and another over the tops of the cars at such a level that the men standing on this runway can bar down the coal without danger of falling. A railing around the runway further adds to the safety of this position.

How a Steel Stack Was Removed and Reinstalled

By Clifford A. Elliott*

The removal of a steel smoke-stack 7 ft. in diameter from the Vineyard power house of the Pacific Electric Ry. and its reinstallation at a new power plant situated at Torrance was decided upon as an economical measure. The boilers which this stack served at the Vineyard Station were no longer in service, and so the stack was not being used. It rested upon boilers 12 ft. high. Forty feet of the stack extended between the top of the boiler and the roof, and the remaining portion, 55 ft. in length, projected beyond the top of the roof.

Owing to limited building space, the removal of this stack intact was not possible as it could not be lowered through the roof of the power house and be removed through the doors or windows of the building. A contractor was found, however, who was willing to undertake its removal in two sections. This was the method finally adopted. A large steel beam which extended through the roof as a part of the construction of the Vineyard power house offered a most favorable and substantial support for the installation of a gin-pole and its rigging for handling the stack. A gin-pole was installed and the hoisting line was run down through an opening in the roof to the boiler room and outside the power house to a donkey engine. The section of the stack extending beyond the roof was first released and was lowered by the aid of the gin-pole to the roof. It was then moved over the surface of the roof on rollers for a distance of about 40 ft. to the building line. The gin-pole was then reset, and by its aid the stack was lowered over the side walls of the building to the adjoining power-house grounds, a height of approximately 50 ft. The second section of the stack, 40 ft. long, extending between the top of the boilers and the roof, was then lifted and placed on the roof, from which it was lowered to the ground in the same manner as the upper section had been handled. The total expense of this removal and relocation of the stack will not exceed $600, says the *Electric Railway Journal*, and will show a substantial saving over the cost of a new stack at the present high market prices. The distance between the two power houses is twenty miles and the stack was transported with motor trucks. The Torrance power house, which is at present about 35 per cent. finished, will serve the new power repair shops of this company. The stack when reërected, will serve two 250-hp. boilers, which are also being transferred from the Vineyard power plant to the new power house.



VINEYARD POWER HOUSE BEFORE STACK (THE LARGE STEEL ONE) WAS REMOVED

Wherever possible install thermostatic traps on larger heating coils and regulate the amount of heat desired in the coil by the supply valve. This, however, can be done only when the return is water-sealed or has a check valve or is drained to a vacuum return line. Best results are secured with radiators of the hot-water pattern, with the steam supply at the top of radiator and return at the bottom.

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Burning Coals of the Southwest

BY W. M. PARK.

Construction Engineer, Green Engineering Co., East Chicago, Ind

Characteristics of the wide variety of coals found in this region. The need of large furnace volumes, liberal grate area and unusual quantities of refractory material in the ignition arch and bridge-wall.

PRODUCTION of coal in the Southwest fields of the United States has not kept pace with that of Eastern fields, owing to the smaller demand on account of the extensive oil developments of that section, the lesser density of population and fewer manufacturing enterprises. The quality of coal in this region varies from a good grade of anthracite containing 14,000 B.t.u. to low-grade lignite of 6000 B.t.u. The anthracite field, which is in New Mexico, is of limited area and is mentioned merely to indicate the contrast in fuel quality found within a small radius.

In the Southwest the majority of coals contain ash in excess of 15 per cent. and of a composition that fuses readily into a sticky clinker. In stoker operation agitation of the fuel bed and the slicing required in hand firing aggravate clinker formation and make continual operation prohibitive except at low combustion rates.

During the last eight years progress has been made in the design of furnaces that will handle these coals successfully, so that engineers now have the same assurance of ultimately satisfactory results that is felt when designing furnaces for Eastern coals. In the following reference is made to a few modern settings from which creditable performances have been secured.

Fig. 1 shows a horizontal-pass boiler equipped with a chain grate having a ratio of grate area to steam-making surface of 1 to 52. This furnace readily ignites and burns 40 lb. of coal hourly per square foot of grate and under test conditions has given 72 per cent. efficiency when burning a New Mexico coal of the following analysis:

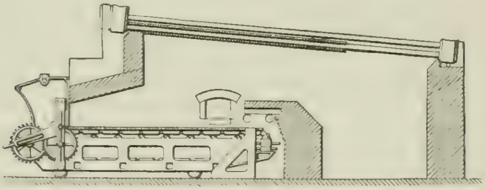


FIG. 1. CHAIN GRATE SERVING HORIZONTALLY BAFFLED BOILER

Moisture, per cent	17
Volatile, per cent	33
Fixed carbon, per cent	33
Ash, per cent	17
B.t.u., commercial basis	8,500

The higher-grade coals of New Mexico are used quite extensively in El Paso, Tex., on a number of chain-grate installations. These coals are all rich in volatile, and some appear to contain, either in the volatile matter or in the lighter particles of ash, some element that attacks even the best grades of firebrick, if the furnaces are designed to give high gas velocities.

A furnace for a vertically baffled boiler is shown in Fig. 2. The outstanding feature of the design is the ample combustion chamber provided by headroom of 11.5 ft. under the bottom of the front header. The high-set sloping arch in connection with a vertical bridge-wall gives intense reflection and radiation of heat on the entering fuel, and a large opening between the arch and the bridge-wall insures nominal gas velocity. This type of furnace has given highly satisfactory performance, operating continuously at averages of 15 per cent. CO$_2$ and 2 to 3 per cent. ashpit loss when burning northeastern and north-central New Mexico coals with the following representative analysis:

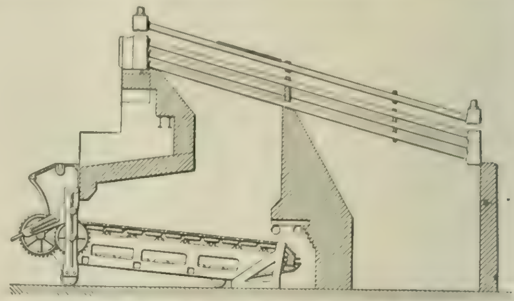


FIG. 2. AMPLE COMBUSTION CHAMBER, HIGH STEEP ARCH, LARGE GAS OUTLET

Moisture, per cent	2.87
Volatile, per cent	34.27
Fixed carbon, per cent	46.08
Ash, per cent	16.78
B.t.u., commercial basis	12,023

About sixty miles west of Ft. Worth, Tex., is an isolated bituminous coal field of small area. The screened-lump grades of this coal have a heat value of 12,500 B.t.u. A large percentage of the output is used by the Texas & Pacific Ry., leaving a limited amount for domestic consumption in a territory traversed by this railroad. The screenings are burned on chain-grate stokers at several of the mine plants and at a large public-service plant in Ft. Worth. The better grades of screenings have a heating value of 10,500 B.t.u. while the lower grades run as low as 8300 B.t.u. and have a proximate analysis of:

Moisture, per cent	3.50
Volatile, per cent	30.70
Fixed carbon, per cent	26.24
Ash, per cent	39.56

To burn this coal successfully it is necessary to cover approximately 90 per cent. of the furnace with an arch set with a steep slope and ample height, which in combination with a vertical bridge-wall gives intense reflection of heat upon the fuel bed at the entrance to the furnace. This furnace is shown in Fig. 3. Naturally, it is necessary to provide unusually large grate area to burn sufficient quantities of this low-grade fuel. Some of the stokers at the mines have a ratio of grate area to steam-making surface as low as 1 to 25.

In the western counties of Arkansas there is mined a grade of coal known as semi-anthracite, having the following average analysis:

Moisture, per cent	3.5
Volatile, per cent	14.0
Fixed carbon, per cent	60.5
Ash, per cent	22.0
B.t.u., commercial basis	11,400

The glossy appearance of freshly broken pieces and the nature of the fracture is similar to that of Pocahontas coal. The percentages of volatile matter and moisture also approximate those of the latter fuel, but the different nature of the volatile and the considerably higher percentage of ash give the coal characteristics in burning that are quite different. When heated, the tars appear to volatilize before they reach the temperature at which they would become plastic as contrasted with Eastern coking coal. Instead of caking together in lumps, the smaller chunks disintegrate under heat so that the fuel bed is like a mass of loose sand. Because the coal has these characteristics, it produces a dense fuel bed, and therefore the depth of fire must be less than that used with high-volatile coals for corresponding drafts and combustion rates.

These low-volatile coals are perhaps the most difficult fuels to burn of any encountered in this district, on account of the difficulties of ignition. Even with the furnaces designed for the most intense concentration of heat at the ignition point, semi-anthracite coals will ignite only on the surface if radiant and reflected heat alone are depended upon. The ignition of fuel in the lower part of the fuel bed can be accelerated by the use of a special grate having corrugated face tile in contact with the fuel.

Fig. 4 shows an experimental design of furnace first worked out for semi-anthracite coal. It involves an expensive lot of special tile shapes, and the maintenance of the brickwork is high. Equally good results may be expected with the simpler type of arch shown in Fig. 2, though for the boiler and for the length of stoker shown in Fig. 4 the furnace projection and length of arch should be increased when the reversed arch is eliminated.

From a long series of tests of from eight to twenty-four hours' duration, six tests are presented in the accompanying table. Efficiencies as high as 78.5 per cent. were obtained where unusual pains were taken to maintain steady conditions, but the list chosen does not include the maximum efficiencies. Tests typical of results readily obtainable are of greater value to the engineer, and this point was borne in mind in making the selection.

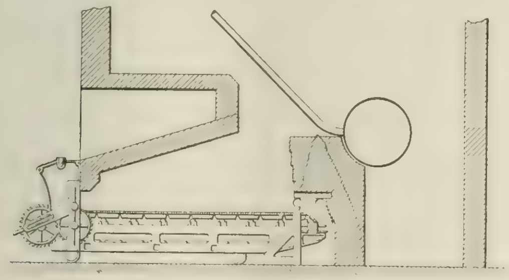


FIG. 3. HIGH STEEP ARCH COVERING ABOUT 90 PER CENT. OF FURNACE WITH VERTICAL BRIDGE-WALL CAUSES INTENSE HEAT REFLECTION

The writer's experience in burning the Southwestern coals leads to the following conclusions:

On account of the high ash content and the fusible nature of the ash, these coals can be burned with highest efficiency and least labor on a chain grate.

Most of the coals are of high volatile content, ignite readily and burn freely if provided with long, high-set arches.

Semi-anthracite ignites least readily, but if load conditions permit maintenance of steady furnace conditions, this fuel can be burned with high efficiency. With liberal grate area substantial overloads are possible.

As semi-anthracite crumbles in the fire rather than caking together, it is desirable to reduce the sifting of fuel and resulting holes in the fire by use of a stoker chain having finely divided and ample air space.

To secure high furnace efficiency at high rating, a large furnace volume is desirable. This is insured by setting horizontal water-tube boilers at a front-header height of 8 to 10 ft. if horizontally baffled, and 10 to 13 ft. if vertically baffled, above the floor.

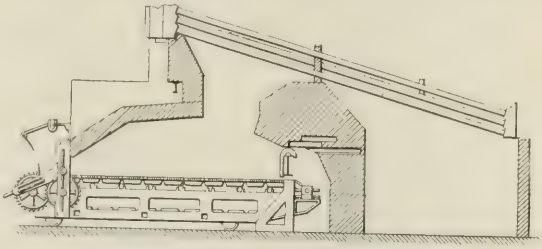


FIG. 4. EXPERIMENTAL FURNACE SUCCESSFUL IN BURNING SEMI-ANTHRACITE COAL

Provision should be made for furnace draft of 0.30 to 0.60 in. over the fire, and liberal grate area should be furnished to insure good overload capacity when burning the medium and lower grades of these coals.

RESULTS OF TESTS ON COALS OF THE SOUTHWEST

	Name of Coal					
	Jenny Lind, Ark.	Gallup, New Mex.	Raton, New Mex.	Strawn, Tex.	Dewar, Okla.	Huntington, Ark.
Moisture	4.25	19.55	2.45	2.81	6.27	3.88
Volatile	14.28	69.53	34.99	35.41	27.93	16.93
Fixed carbon	58.89	..	46.08	40.23	46.37	56.06
Ash	22.58	10.92	16.48	21.55	19.43	23.13
B.t.u. per lb. as fired	10,874	8,367	12,059	11,200	10,706	10,912
Per cent. comb. in refuse	22.9	.....	15.9	22.3	26.9	19.8
Furnace draft, in.	0.27	0.27	0.12	0.11	0.23	0.38
Flue gas temp., deg. F.	463	584	507	477	520	444
CO_2 at furnace	13.5	15.5	15.6	12.2	12.6	12.4
CO_2 at uptake	12.9	10.0	11.7	9.7	10.0	11.6
Coal burned hourly per sq.ft., lb.	32.1	40.2	26.6	24.65	27.5	28.5
Per cent. builder's rating developed	170	146	154	134	139	148
Combined efficiency	74.1	71.8	72.8	73.6	71.7	72.2

Exports of crude oil and petroleum products from the Tampico district to the United States during 1918 amounted to 39,618,121 barrels.

The Clinker Grinder

Burning coal containing 12 per cent. ash and evaporating 6.9 lb. of water per hour from and at 212 deg. F. per sq.ft. of heating surface, a 15,000-sq.ft. boiler will accumulate in its furnace more than 5.5 tons of ash per hour. For Western coals more than half this will be clinker. Large plants with careful, competent labor are getting away from handling the clinker and ash by hand and are breaking and discharging it by machinery. Next week's "Power" will have an article treating of the development, design, operation and performance of modern clinker grinders.

Rebuilding a Commutator under Difficulties

By H. Wilson

It is not always feasible to use orthodox methods when confronted with a hurried repair job in an awkward corner. One has just to devise the best means to suit the situation no matter what rules and regulations are broken.

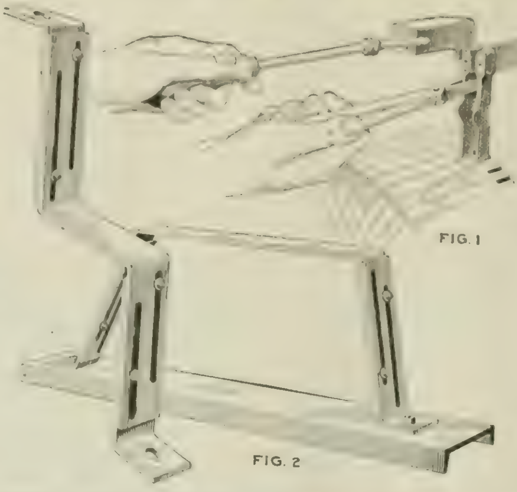


FIG. 1

FIG. 2

FIGS. 1 AND 2. METHOD OF UNSOLDERING ARMATURE LEADS, AND A TOOL REST FOR TRUING UP COMMUTATOR

The main ventilating unit of a large department store broke down during a period of very hot weather. This large fan was direct-driven by a slow-speed direct-current motor. On investigating it was found by a magneto test that the armature was grounded, and on making a drop test with a millivoltmeter the trouble was located on about six bars of the commutator. There was no sign of the trouble on the surface of the commutator, so it was evident that it would have to be taken apart and possibly reinsulated.

At first it was thought that the work should be given to some outside firm, as it seemed impossible to do it with the limited means at our disposal; but after due consideration it was decided to undertake the job.

A chain block was put up overhead and the top half of the motor-field frame lifted off. The front bearing pedestal was then removed temporarily, in order to get the brush rigging off. The armature was bar-wound, the risers from the commutator bars being very close together. In order to unsolder them quickly, two irons were made of a special shape to suit the job, and a gas stove was connected alongside. When sufficiently heated, the risers were pulled clear of the winding with a pair of long-nosed pliers, as in Fig. 1. A strong band clamp was placed around the bars, and after removing the end ring the commutator was carefully taken off the boss, the bearing pedestal having been removed again for this purpose. The back bearing cap was loosened up and the armature allowed to rest on the bottom polepieces. On examination it was found that a section of the commutator had grounded onto the back ring and also that several bars had fused together underneath. The inside was quite moist, and the cast-iron boss was also in the same condition. Before taking the commutator apart, a larger piece of wood was turned to fit snugly inside of it. This allowed the bars to be drawn up true when building the commutator up again, without the aid of expensive clamping rings. All the micas were taken out and dried and the edges scraped, defective ones being discarded and new ones cut. The damaged part of the V-ring insulation was replaced with new mica. The bottom edges of all the bars were slightly beveled by means of a smooth file, and all excess solder was removed from the riser lugs with a gasoline torch. The commutator was then put together on a flat table, the bars being placed, with the risers down, and all around the wooden block previously prepared, then drawn up tight with the clamping band under which was placed a strip of fiber insulating paper.

After testing for short-circuits, the commutator was ready to be put back. The ends of the armature leads were cleaned and straightened out and all pieces of solder carefully picked out of the windings. After the commutator was replaced, it was heated to loosen up the shellac on the end V-rings, and the bolts were pulled up tight. The conductors were then soldered into the risers. The next operation was to true up the surface of the commutator.

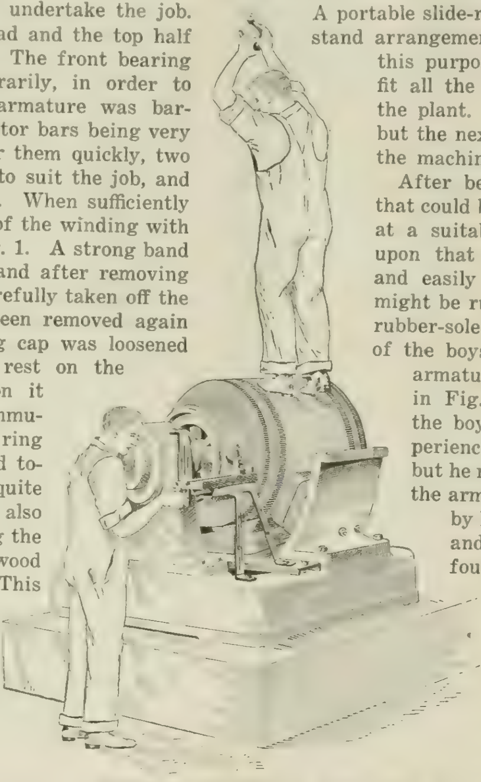


FIG. 3. METHOD OF TURNING ARMATURE TO TRUE UP COMMUTATOR

A portable slide-rest outfit with an adjustable-stand arrangement, Fig. 2, was available for this purpose. It had been designed to fit all the engine-driven generators in the plant. This was easily rigged up, but the next problem was, how to drive the machine.

After being unable to find a motor that could be used to drive the armature at a suitable speed, the idea was hit upon that the armature being heavy and easily kept moving, once started, might be run by foot-power. A pair of rubber-soled shoes was secured for one of the boys around the plant and the armature was revolved as indicated in Fig. 3. I don't know whether the boy had had any previous experience on the treadmill or not, but he made a good show at it. Once the armature was started revolving, by holding on to the chain block and running on top, it was found possible to take a fine cut off the commutator. This method was a bit slow of course, as the "engine" gave out occasionally, but it accomplished the purpose and it is doubtful if any simpler form of drive could have been devised for revolving an armature in its own bearings.

EDITORIALS

Conservative Claims of Interconnection Benefit

TYING together of steam plants to take mutual advantage of local differences in load conditions and capacity available at various periods is becoming more and more popular in the field of power supply. It is the duty of the industrial-plant engineer to "sit in" at any conference considering the making of a contract for interchange or for off-peak purchase of energy, and in such cases a thorough knowledge of the probable effect of different operating plans, based if possible upon experience, is decidedly worth while.

There is sometimes a temptation to exaggerate the savings secured by the purchaser of energy and to minimize the benefits conferred by such an arrangement upon the plant that sells the larger portion of the power involved. The industrial-plant engineer should not overlook the benefit his load may create with respect to the load factor of the system or station from which it is suggested that he take off-peak or other surplus energy. He must also recognize the fact that as soon as his own plant output is reduced through the substitution of purchased power, the tendency will be for the local station efficiency to fall unless the units are handled with great care. This increase in efficiency, which a desirable load may bring to pass in the case of the outside supplying organization, is an asset of no mean value.

In a representative instance of energy interchange the coal consumption of the larger plant was reduced from 2.08 pounds per kilowatt-hour to 1.85 pounds in a single year in which the plant output increased from twenty-two million to thirty-three million kilowatt-hours. A neighboring station increased its energy purchases from this station during this period from three million to fourteen million kilowatt-hours. This additional load was most welcome to the larger plant, a tidewater installation of seventeen thousand kilowatts rating. The smaller plant, rated at 4150 kilowatts, encountered a loss in efficiency during the year expressed in the rise of its coal consumption from 3.08 to 3.54 pounds, its own output falling in this period from twelve million to five million units. The interconnection enabled about four million more kilowatt-hours to be turned out by the two plants for practically the same combined coal consumption. There was therefore a net gain through the arrangement, but there was no ground in the case in point to claim that the big plant was doing everything for the smaller station and should therefore have the lion's share of profit in the contract arrangements. The cost of coal rose during the year from about five dollars to eight dollars and fifty cents per ton. The cost of production per kilowatt-hour actually turned out in the smaller plant during the year increased about one cent.

These figures indicate that it is not all "velvet" for a smaller station to purchase energy of a larger one; in other words, the profits of an interconnection carefully worked out and operated with engineering skill may be real and realizable, but may not be as large as the outside plant representatives would perhaps be tempted to assume. It is fair to recognize the *quid pro quo* of such situations. Here, and in numerous other instances, the larger station not only secures a better load factor and corresponding increase in operating efficiency, but enjoys the advantages of being connected with a source of reserve power that can be utilized on short notice. This means that the larger station need not expend as much money on extensions at a time when the first cost of plant equipment is at the upper levels reared by the demands of war service. On the other hand, the interconnection means that the smaller plant can take on a larger connected load and handle bigger peaks without making an investment in additional units of generating capacity. These considerations point the way toward a thorough analysis of production efficiency from various angles before the papers are finally signed. There are a good many different "slants" to this business of interplant contracts, and the engineer who fits himself to take part in such investigations and to bargain in a businesslike manner for his superiors' interests does well indeed.

Find and Fix the Cause

IT IS not always easy in the course of the day's work, when one is busy with a myriad of things that must be done and with fixing up after things that *have* happened, to find the time and the mental freedom to run in imagination through the things that *may* happen in the plant, and head them off. And yet how many a great catastrophe might have been averted by timely attention to some very little thing! Thorough, systematic inspection will go a long way if one does not fall into a habit of regarding it as routine and get too perfunctory about it. An indication too subtle to make its impression upon any other than a trained, interested and intent observer may, if its cause and meaning be ferreted out, reveal a serious waste or an imminent breakdown.

When something persists in going wrong, one should not be contented with fixing it up for the time being, but should seek it out to a finality and see what is causing the trouble. A joint that leaks persistently may mean an excessive stress in the piping, a leaky boiler rivet may mean an incipient seam crack, a bearing that persistently heats may mean dangerous deflection, a flywheel bolt that continually loosens or breaks points to a condition that should be corrected before something more serious happens.

A case in point occurred recently. The small bolt that held the latch block of a Corliss engine was continually stretching and breaking. In this case the trouble was in the bolt itself or the manner of its attachment, but instead of putting in a bolt of the proper size and material, correctly shouldered and fitted and held firmly in place with a castellated nut secured with a cotter pin or other fastening, the engineer was content to keep a supply of spares and replace the faulty bolts as they broke. One day the bolt just stretched or worked out enough to allow the latch block to cock up so that the hook engaged it but could not let go, with the consequence that the engine took steam for the full stroke on that end in spite of anything that the governor could do and ran away, scattering its flywheel about the premises.

A thorough investigation of the cause of the recurrent trouble and the removal of that cause would have saved a lot of trouble and money. The engineer might not have got a large meed of credit for the job. It is usually not the things that he prevents from happening, but the things that do happen, that are known and credited to him. But he would not be worrying over another accident.

Stinginess Shackles Prosperity

EXCUSES for failure to purchase Liberty Bonds are the easiest things in the world to make and the hardest to justify. Many a reason that sounds plausible to the bond solicitor and that might possibly pass the scrutiny of a critical public is thrown out of court before the bar of conscience, the keenest and fairest judge in the world.

A lot of people fool themselves into believing that they cannot afford to invest in bonds. The bald truth is that they cannot afford not to. Particularly is this true of the Victory Loan, because it is so closely bound up with the industrial prosperity of the nation.

Observe what would happen if the people of America should ignore the coming appeal and should insist on letting the banks respond to it. The banks could probably absorb the full amount of the loan, but they would have little money left to lend to business enterprises, and the interest rates on that little remainder would be exorbitant.

The immense industrial system of the country is built on credit. Shortage of available funds in the banks to meet the needs of business would mean restriction of credit. Thus, industrial organizations of all kinds would be prevented from taking advantage of opportunities for legitimate expansion or for ventures into new and promising fields. The natural consequences would be decrease of industrial activity, increase of unemployment, hard times and widespread unrest. In other words, popular deafness to this appeal would be a boomerang that would knock the props out from under the platform of prosperity.

This is no fancy drawn from a troubled dream. It is a hard-headed fact taken from the book of experience. Volumes of optimistic talk and columns of cheerful interviews will not furnish the financial backing needed to push business. But the savings of millions of Americans from the earnings of the next few months, invested in Victory Notes and thus turned back into the channels of business, will sidetrack much of the trouble that is now approaching. Discontent does not flourish among workers that are busily engaged in useful and gainful occupations.

Prosperity is a condition of business—not a state of mind. Therefore, the way to improve it is to get behind it financially instead of rhetorically.

In plain language, boost the Victory Loan with hard cash as well as oratory. By so doing you will help yourself as much as you will contribute to the aid of the Government

Photographing Injuries

IT HAS been common practice for engineering construction companies and others to keep on file photographs showing the progress made in the construction of the plant that is being built. These photographs, which are marked with the dates on which they were taken, form pictorial evidence of the progress of the development from the beginning to the finishing of the work.

Photographic evidence is accepted by the courts and many cases have been decided by it. This form of evidence might be employed to advantage by both the employer and the employee in cases of accident. Such evidence could be used by the one party to show the extent of the injury and by the other party to show whether an injury had been or had not been received. Of course this would not be possible in cases of internal injury, but burns and external cuts and bruises could be clearly shown.

If photographs were taken of all accidents and injuries there would be less chance for controversy as to the character of the injury in cases where the two interested parties could not get together, or adjust a satisfactory settlement. It would also seem that there would be less chance for fraudulent claims on the part of the one and the successful evasion and unjust settlement on the part of the other if this were done.

Our attention was recently called to a system of piping in which hot salt water was circulated, and although this piping was lead-lined, it deteriorated rapidly and in this particular case did not seem to give any better satisfaction than ordinary pipe. It is well known that hot salt water has a very deteriorating effect upon piping, but why it should attack lead-lined piping is somewhat puzzling. Perhaps some of our readers have had experiences that others would be glad to know about.

Judging from the numerous letters that have been published lately regarding the flooding of radiators in low-pressure steam-heating systems, it would seem that designing engineers of such installations have something to learn regarding such matters, or that they are willfully neglectful in putting in a system that will give satisfactory service.

One reason why piston-rod packing burns out is because it is not properly placed in the stuffing-box. Almost anyone can jam a lot of packing around a piston rod, but the man who knows how to do it properly will save the firm money in the cost of packing and himself a lot of trouble.

The chap who continues to write and speak of anthracite coal would probably be moved to uproarious laughter if he heard someone else mention hydraulic water or igneous fire.

A "Safety First" sign fell from a post and knocked a workman unconscious. He now is probably convinced that there is something in the popular slogan.

With the wide-awake fireman, excess air is just about as popular as an attack of influenza.

Correspondence

Using a Spare Boiler as an Economizer

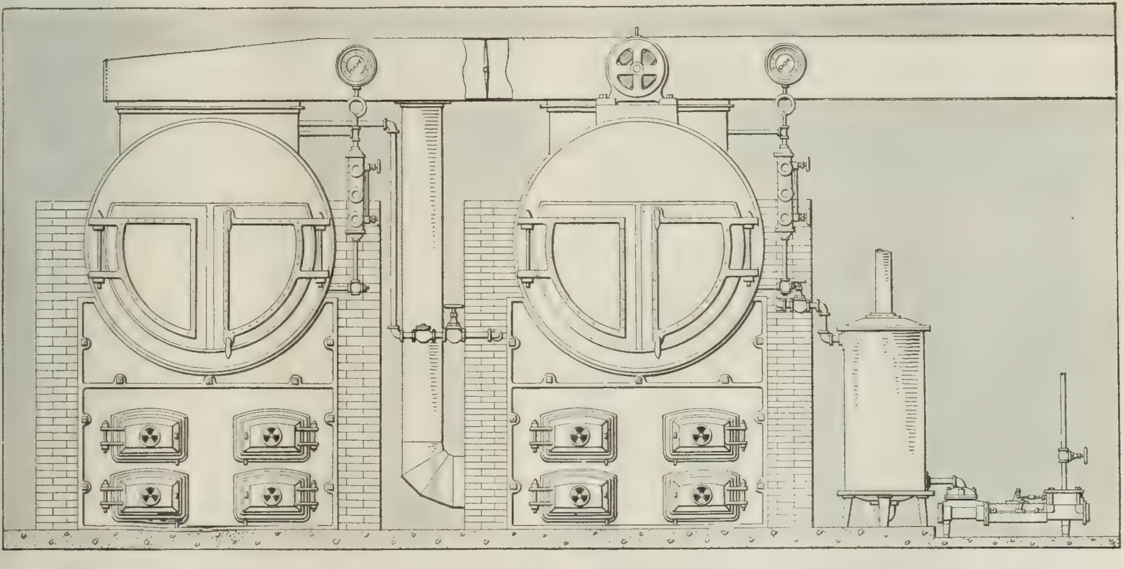
In steam plants operating without economizers but having a spare boiler, considerable economy can be obtained and additional capacity gained by the use of the spare boiler as an economizer. In most plants very little expense would be incurred to put this plan into operation. The gases of combustion would be bypassed from the breechings of the live boiler or boilers, through a duct leading under the ashpit of the spare boiler. A greater draft would be required to draw the gases through the duct and the extra boiler setting, but the same is true of any economizer. This draft could be easily supplied by a suitable fan driven by an engine or a variable-speed motor in case the natural or stack draft was not sufficient.

The piping connections would be arranged to feed all the water into the "economizer-boiler," which should be subjected to steam pressure from the other units, maintaining a slightly higher water level in the "economizer-boiler" so that it would flow by gravity to the boilers being fired. This method would be preferable to carrying the boiler full of water, as injury to safety valves might result from this practice. In case more than one boiler was being fired, the feed water would be controlled by a valve for each one, but with only one boiler being fired the feed would be controlled at the pump and the water level in the economizer would be only slightly higher than that in the boiler.

This plan offers a means of utilizing otherwise idle equipment and increasing the plant efficiency to a high degree, and it does not conflict with insurance regulations.

Allard C. French.

San Angelo, Tex.



SHOWING HOW A SPARE BOILER MIGHT BE USED AS AN ECONOMIZER

Advocates Standardizing Pipe Unions

The fact that the various makes of pipe unions differ slightly, preventing the parts of one being used with the parts of another, leads to unnecessary waste, especially when tearing down pipe lines. For instance, injectors, etc., naturally come apart at the unions, and few workmen take the trouble to remove the disconnected pieces of unions from the pipes and connect them for use again, therefore many ejectors, injectors and ordinary pipe unions are thrown into the scrap as a result.

Why would it not be a good idea for manufacturers of pipe unions to agree on a standard for dimensions? There should also be standards for ground-joint unions. For instance, because of the cracking of a nut on a radiator-valve union probably not worth over 25 cents, I was obliged to buy a new valve costing $2, and furthermore to go to considerable trouble to unscrew part of the union out of the radiator and get the valve off the pipe. That was a waste of material and of effort.

Is there any more reason for each manufacturer having his own particular standard dimensions of unions than there is for each having his own standard pipe threads?

I will venture to say that if such a standard for unions were adopted, no customer would be greatly inconvenienced even temporarily; and the eventual saving would be considerable to many thousands of users.

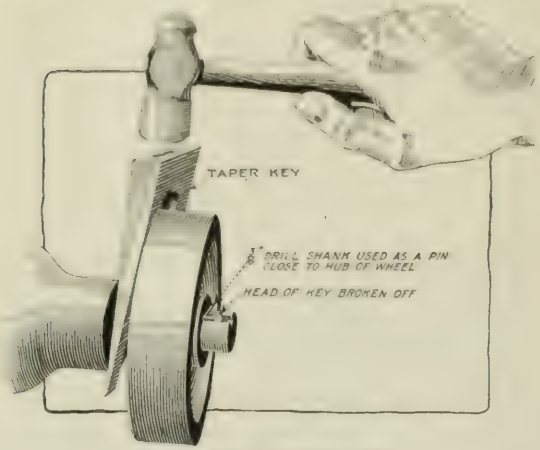
I would like it if the American Society of Mechanical Engineers would appoint a committee for the purpose of adopting a standard that manufacturers would agree to use.

F. D. Buffum.

Pittsburgh, Penn.

Removing Key from Motor Shaft

The illustration shows a kink that may be used when removing a pulley fitted with a taper key on which there is no head. The pulley is driven on the shaft as far as possible, and then a small hole (say $\frac{3}{16}$-in.) is drilled with a breast drill in the end of the key close to the hub of the pulley. A piece of round steel is put in the hole and the pulley is forced off with the split wedge as shown. All that is required of the pin in the drilled hole is to overcome the friction between the key and the shaft, which is not great if the pulley is not again driven onto the taper.


TAPER KEY
3/16" DRILL SHANK USED AS A PIN CLOSE TO HUB OF WHEEL
HEAD OF KEY BROKEN OFF

REMOVING A BROKEN KEY

Lima, Ohio. B. C. **Malick.**

What Are They Waiting For?

The present observed reluctance to spend money for power-plant equipment is so marked and so obviously wasteful that I am impelled to comment thereon. Buyers have frequently said that they are waiting for lower prices; and it is this attitude that is bringing the country to the verge of panic conditions. I can fully understand and appreciate the reason for this attitude with certain types of investment, but when it comes to such devices as mechanical stokers, the argument no longer holds.

Compared with hand-firing, the stoker will save from 15 to 20 per cent. of the coal. Seldom does the average efficiency of a hand-fired boiler exceed 55 per cent.; and more often than otherwise does the average of stoker firing exceed 65 per cent. As a matter of fact, hand-fired over-all boiler-room efficiencies are nearer 45 than 55 per cent. An increase of 10 per cent. in efficiency would mean an increase of 15 or 20 per cent.. as compared to previous operation; and this is what counts.

With coal at $3 per ton, a stoker operating at normal rating will at $10 per rated horsepower installed, give a return of 66 per cent. In the face of this fact someone must get busy to justify the waiting attitude. At the end of a few months the watchful waiter would have to get his stokers for nothing if he did not want to lose money. Every day he waits adds to his loss; and no possible reduction in price will begin to offset the loss due to his ever-present combustion inefficiency. Delay under such circumstances is economically unjustifiable.

Chicago, Ill. Joseph **Harrington.**

Lamp Kept the Meter Warm

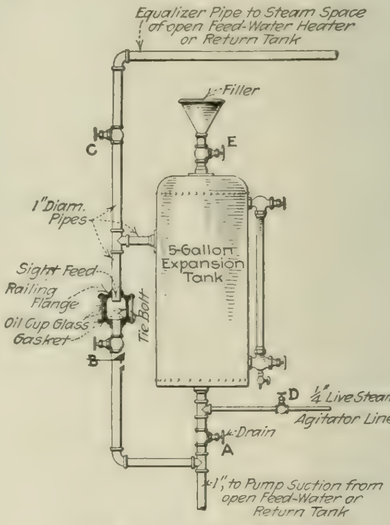
After having considerable trouble in getting a clock in a graphic meter to run, and noticing that it ran better on warm days than on cooler ones, a small carbon-filament lamp was placed in the meter and connected to a 110-volt circuit. After the lamp had raised the temperature in the meter case, the clock ran all right. It was decided that the oil became thick when cold and retarded the action of the clock movement. When the lamp warmed the inside of the meter, the oil thinned and the clock ran as it was intended.

Norristown, Penn. William H. **Watson.**

Home-Made Compound Feeder

The sketch shows a boiler-compound feeder that was developed by the supervising engineer of a concern having a number of plants, and sent to the engineers in charge of them. Accompanying the sketch was a circular letter with instructions as to the use of soda ash and graphite, and the formula for the boiler compound formulated by the supervising engineer, with instructions for its use and the method of testing the boiler-feed water to determine when sufficient compound was being used. The illustration is self-explanatory, and the directions for using follow:

The expansion tank is placed above the water line of the open feed-water heater or return tank and piped as shown. To operate, put the amount of compound required for twenty-four hours, mixed with sufficient water to flow freely through the filler funnel, into the tank, valves *A*, *B*, *C*, and *D* being closed. Then put more water in the tank to bring the level up to the overflow pipe. Next close valve *E* and open valves *B* and *C* and then the valve *D* just sufficient to keep the tank agitated and the condensation overflow through the pipe and valve *B* into the pump suction.


Equalizer Pipe to Steam Space of open Feed-Water Heater or Return Tank
Filler
E
C
1" Diam. Pipes
5-Gallon Expansion Tank
Sight Feed
Railing Flange
Oil Cup Glass
Gasket
Tie Bolt
B
D
1/4" Live Steam Agitator Line
Drain
A
1", to Pump Suction from open Feed-Water or Return Tank

PIPING OF COMPOUND FEEDER

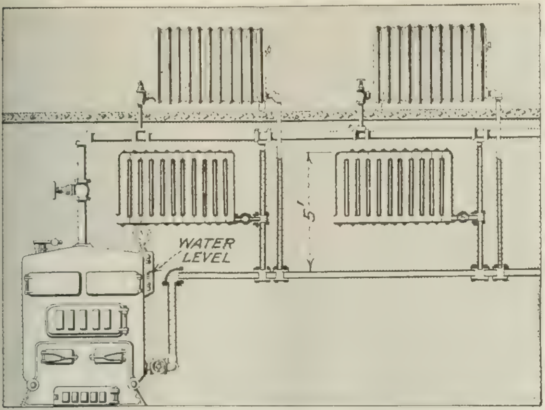
When it is necessary to refill the expansion tank, open valve *A* and allow sufficient liquid to flow into the pump suction to make room for the new charge. Then close the valves *A*, *B*, *C* and *D*, fill through the valve *E*, and proceed as before. W. T. **Meinzer.**

Brooklyn, N. Y.

Firing Low-Pressure Boilers

The theory presented by J. M. Coleman, on page 837 of the Dec. 10, 1918, issue of *Power*, regarding the peculiar action of some low-pressure boilers does not seem to me to be correct. Hard firing ought to make the water lighter as it would then be filled to a greater extent with globules of steam.

I recollect an instance somewhat similar to that related by Mr. Coleman. The owner of a building installed a sectional cast-iron heating boiler, but instead of excavating for the boiler setting in order to secure a head, as he had been advised to do, he saved the price and set the boiler on the floor. The result was that there was a head of not more than five feet. The radiators were equipped with motor-seal valves from which the floats had not been removed. The heating system had previously been used as a vacuum return. I knew the caretaker and advised him never, under any circumstances, to raise the pressure above about two pounds.



LOWER RADIATORS FLOODED WITH CONDENSATE

A "howl" was made for heat, however, and in order to be agreeable he raised the pressure. The result was a melted fusible plug and several cracked boiler sections. My reason for advising him as I did was that, as the motor-seal valves would permit nothing but condensation to pass, the effort of the pressure to equalize on both sides of the valves would hold the check shut until a sufficient head of water had accumulated to balance the boiler pressure plus the weight of the check.

As the water in the return had to rise only about five feet to be up to the top of the lowest coils, a large storage capacity was provided for the returning condensation, and the fireman happened to be away at the psychologic moment, or he might have kept the boiler supplied with water. He saw the reason when he had the proof and did not raise the pressure above two pounds again.

Toronto, Ont., Canada. R. McLaren.

Was This Armature Burnt Out?

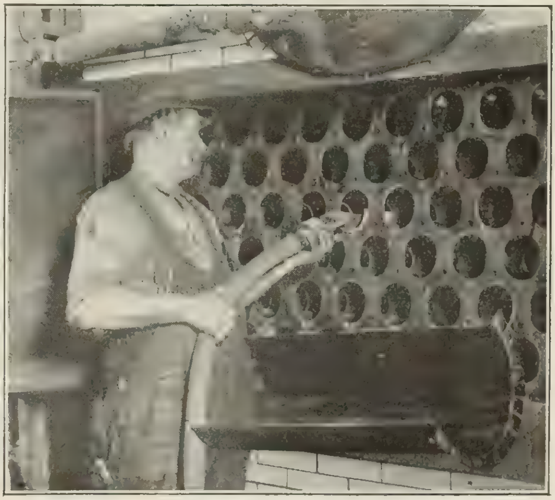
For approximately six years a 10-kw. three-phase 25-cycle converter had been in service twenty-four hours a day. In addition to the strain of such continuous service the location was very much against the machine. The converter was mounted above the switchboard frame in a storage-battery assembling and charging room. The air was filled with sulphuric-acid fumes and a heavy black smoke, the latter being given off by the pots of hot pitch. The armature was recently taken out and sent to a motor-repair shop to have the rings and commutator turned down. After turning the rings and commutator the motor foreman notified the owner that the armature winding was burnt out and would have to be rewound. On inspecting the armature I came to the conclusion that the winding had at some time been quite hot and that it had been impregnated with an insulating paint, which caused it to be very hard and give off a sound similar to that of a burnt winding, when struck with a light hammer. The armature was put back and the machine started in service. Everything went well for about an hour, when a flash was seen and the circuit-breaker opened. It was supposed that the armature had burnt out, but all the coils were cool.

The trouble was found to have been caused by a flash from a brush-holder to ground. When the insulation on the brush was cleaned, the former was found to have been carbonized by a slow leaking of current through the oil and dirt. The brush-holder was taken out and a piece of composition mica board heated and bent around the square part of the stud, the brush-holder replaced and the machine put into service. The converter is now carrying its load twenty-four hours a day without any sign of distress. R. L. Hervey.

Washington, D. C.

Guide For Tube Cleaner

For removing scale from water-tube boilers I have been using a water-turbine cleaner. To enter the cleaner in a tube it was necessary to put one hand through an opening in the handhole plate to keep the cutter wheels together. Recently, a way was found to eliminate the work of guiding the cleaner by hand. A piece of sheet iron was shaped into a half-circle, the length being sufficient to project from the handhole plate a short distance into the tube. The outer end was flanged over and the device placed in the position shown in the illustration. It guides the cleaner right into the tube and prevents the wear of the hose on the sharp edges of the handholes. E. G. Carlson.



CLEANER GUIDE AND ITS APPLICATION

Chicago, Ill.

Comments on the Mobile Boiler Explosion

After reading the account of the Mobile boiler explosion and also the letters by E. R. Fish and A. G. Pratt, on pages 465 and 466 of the Mar. 25 issue of *Power*, in which the representatives of the two boiler manufacturers give their theories as to the cause of the explosion, each evidently believing that it was the other manufacturer's boiler that exploded first, permit me to comment on the evidence that has been presented.

First of all, suppose we consider another explosion, which occurred at the Marion Railway Light and Power Co.'s plant at Marion, Ohio, on Aug. 22, 1906. This was an explosion of a Stirling boiler, and the cause was undoubtedly the failure of the blank head on the bottom or the mud drum. This head was corroded, and the break occurred where the head dished the most in turning to make the flange. In this instance, as at Mobile, the boiler was one of a pair, each so set that the blank head of the mud drums came end to end. The accompanying illustration is a reproduction of a photograph of the disk that was blown out of the drum head. The account was published in the *Engineers' Review*, then of Cleveland, Ohio. A comparison of this disk and the one shown in the article describing the Mobile explosion shows them to be almost identical, and the cause of both ruptures was due to corrosion of the head. This, it would seem, emphasizes the contention of Mr. Fish that the Stirling boiler mud-drum head failed first.

MUD-DRUM HEAD FROM MARION, OHIO, BOILER EXPLOSION

Coming back to the case in hand and discarding the theories offered by Mr. Fish and Mr. Pratt, an examination of the approximate plan of the plant offers an opportunity for speculation. As stated in the article, Nos. 4A and 4B Heine boilers were set in one battery, and Nos. 5 and 6 Stirlings were also set in one battery with a space between the settings of the two types of boilers. Assuming that No. 4B Heine exploded first, it would have been blown to the position shown, and No. 4A would have been blown to the position indicated in the plan view published with the article. If Stirling No. 6 exploded a few seconds later it would have been blown to the position shown at the Allis engine, but No. 5 boiler would not have been blown to the position shown as the result of the explosion of No. 6. As a matter of fact, it would have been blown toward the original setting of the Heine boilers, and in an opposite direction from that in which it really did go.

Working on the theory that the Stirling No. 6 was the first to explode, it would have been blown to the position shown, and the force of the explosion would have been such as to shatter and destroy the brick setting of No. 5 Stirling, which it did. Assuming that the Heine exploded a second or two after the Stirling, the results could be expected as were found.

It might be assumed that the force of the exploding Heine boiler would blow No. 5 Stirling to the position shown in the diagram, but the probabilities are that this boiler was blown to its final resting place by the skyrocketing effect resulting from the tubes pulling out of the mud drum.

The indications are, however, that the setting of boiler No. 6 was demolished before No. 5 was blown out of its setting, and if the flight of No. 5 was due to the pulling out of the tubes in the mud drum, it would seem that it would have been blown in the direction of No. 7 boiler, or at a right angle to the direction in which it did go. On the other hand, if No. 6 Stirling boiler exploded first and was followed by that of No. 4B Heine, together with the pulling out of the tubes of the mud drum of No. 5 Stirling, it would appear that No. 5 boiler would have landed just where it did. This would be due to the setting of No. 6 being totally demolished and out of the way and at the same time shattering the setting of No. 5 by the initial explosion of No. 6 boiler. If this was immediately followed by that of No. 4B Heine, the setting of No. 5 boiler would have been demolished from both sides at practically the same instant. The water-hammer set up in No. 5 boiler, due to broken steam connection and the flashing of water into steam, would cause the tubes of No. 5 boiler to pull out of the drum. As the setting of No. 6 boiler was gone, and with the Heine boiler exploding at practically the same instant that the tubes pulled out of the mud drum of No. 5 boiler, the force of the explosion would be to blow the latter to the position alongside of the Allis engine.

One fact regarding the Heine boiler should not be lost sight of, however; that is, that a portion of the back tube header is bent outward and that a part of it was found attached to the rear head of the steam drum, the rivets of which were sheared from the body of the drum. That the rear header was a point of initial rupture in this boiler is evident, and if the boiler was the second one to explode and its explosion was caused by the sudden release of pressure due to the explosion of the Stirling boiler, it would seem that the front header would have been the one to fail instead of the rear one. If, on the other hand, the rear header of the Heine boiler was the first to rupture, it would have been bent out as it was, and the ripping of the steam drum would have been a secondary result of the header failure.

The more one studies the problem the more it becomes evident that it is a difficult matter to determine which boiler failed first, as there are so many conflicting factors to consider. W. H. ROWLAND.

New York City.

The Victory of Prosperity—The Victory Loan.

Inquiries of General Interest

Power Required To Drive an Emery Wheel—Will you publish the formula for figuring the power required to drive an emery wheel. G. L.

There is no method of figuring the power required to drive an emery wheel. However, the power required will depend upon the size of the wheel and the kind of work it has to do. Experience has shown that, ordinarily, a 6-in. wheel requires from 0.5 to 1 hp.; a 10-in. wheel, 2 hp.; a 12-in. wheel, 3 hp.; an 18-in. wheel, 5 to 7.5 hp.; and a 24-in. wheel, 7.5 to 10 horsepower.

Changing the Speed of a Fan Motor—Is it possible to increase the speed of direct-current motors used to drive fans? If so how is it done? A. R.

If a fan is driven by a series motor, the speed of the motor may be varied by connecting a resistance in parallel with the field winding. If the motor is of shunt type, its speed may be varied by connecting a resistance in series with the field winding. The value of the resistance will depend upon how much the speed is increased and upon the size of the motor. It is doubtful if a motor that has been designed to drive a fan of a given size can have its speed increased very much without being overloaded, since a fan load increases as the cube of the speed.

Excessive Size of Pump Suction Pipe—Can a suction pipe of a pump be too large where the length is about 200 ft. and lift 11 ft.? J. S.

The suction pipe should be large enough to keep the velocity of water down to about 230 ft. per min. By the use of a smaller pipe requiring greater velocity there is too much loss of pressure in overcoming pipe friction. The higher the vacuum required at the pump the greater the amount of air liberated out of the water, giving trouble in operation of the pump. On the other hand, when a larger suction pipe is used, there may be less pipe friction from lower velocity, but more time is given for liberation of air from water that is subjected to less than atmospheric pressure. However, the pipe cannot be too large for those portions where the pressure in the suction pipe is above the pressure of the atmosphere.

Why Equal Cutoff Requires Unequal Valve Laps—To obtain equal cutoff with an ordinary D slide-valve engine, why is it necessary to have less outside valve lap for the crank end than for the head end of the cylinder? C. R.

On account of the angularity of the connecting-rod, the first half of a stroke of the piston from the crank end of the cylinder is accompanied by more than one-quarter of a complete revolution of the crankshaft, and the first half of a stroke from the head end is accompanied by less than one-quarter of a revolution. Hence, for any fraction of stroke from the crank end the eccentric is carried through more degrees of rotation than for an equal fraction of stroke from the head end, and if the valve had equal laps, cutoff would occur earlier in the stroke from the crank end than from the head end, and in order to delay closure of the steam port on the crank end to the same fraction of stroke as cutoff occurs for the head end, it is necessary to have less lap of valve for the crank end.

Effect of Increasing Weight of Governor Balls—Would increasing the weight of the flyballs of an ordinary Corliss engine governor cause the engine to be regulated at a higher or a lower speed? I. W. C.

In operation of the pendulum type of governor ordinarily employed on Corliss engines, the arms from which the flyballs are suspended do not attain as great height as would be assumed by a simple revolving pendulum, because part of the centrifugal effort is employed in supporting a central weight, or in overcoming the elasticity of a spring, in addition to sustaining the weight of the balls and arms. Increasing the central weight, or, as well known, adding load to the governor, acts as a greater restraint that results in increase of speed. The cutoff becomes longer because the balls are in lower position for the same speed, and increase of speed continues until the centrifugal effect becomes sufficient to carry the additional burden laid on the governor. Evidently, the same result of speeding up the engine would result from making the governor balls lighter, but the reverse result is obtained either by taking load off the governor or by increasing the weight of the governor balls; that is to say, increasing the weight of the governor balls will result in slower speed of the engine.

Loss from Combustible Remaining in Ashes—What is the loss from combustible remaining in ashes when the coal as fired contains 12,890 B.t.u. per lb. and 12.6 per cent. ash, if the refuse contains 40 per cent. combustible and the coal costs $6.75 per ton? J. A. P.

Each 100 lb. of coal containing 12.6 per cent. ash would consist of $(1 - 0.126) \times 100 = 87.4$ lb. of combustible and 12.6 lb. of ash. If the refuse from firing consisted of 40 per cent. combustible and $100 - 40 = 60$ per cent. ash, then the refuse from firing 100 lb. of coal would contain $12.6 \div 60 \times 40 = 8.4$ lb. of combustible, and the loss of combustible contained in the coal would be $(8.4 \times 100) \div 87.4 = 9.6$ per cent. Hence, if the coal contained 12,890 B.t.u. per lb. of combustible, there would be a loss of 9.6 per cent. of 12,890 = 1237 B.t.u. per lb. of coal; and with coal costing $6.75 per ton there would be a loss of 9.6 per cent. of $6.75 = $0.65 per ton of coal used.

Expressed algebraically, if a = percentage of ash in the coal and c = percentage of combustible in the refuse, then $100 - c$ = percentage of ash in the refuse and $\left(\frac{a}{100 - c} \times c\right) 100 \div (100 - a)$ = percentage of loss. If as in the example, $a = 12.6$ and $c = 40$, by substitution the formula becomes $\left(\frac{12.6}{100 - 40} \times 40\right) 100 \div (100 - 12.6) \doteq 9.6$ per cent. loss.

Operation of an Induction Generator—Will you explain the operation of a squirrel-cage type induction motor when operating as a generator as sometimes used in semiautomatic hydro-electric power plants? J. T.

When a squirrel-cage type induction machine is operating as a motor, its rotor is running slower than the revolving magnetic field and is cutting this field in a direction to set up a current in the rotor of a direction to produce a torque in the same direction as the field is moving. This rotor current is in an opposite direction to the stator current, consequently when operating as a motor the rotor current is a demagnetizing current, which will tend to decrease the strength of the magnetic field and therefore the value of the counter-electromotive force in the stator.

If power is applied to the rotor, as in the case of the induction generator, and driven faster than the revolving magnetic field—that is, above synchronism—its conductors will be cutting the line of force in a direction opposite to that when running as a motor. Therefore, if when operating as a motor, the current in the rotor is a demagnetizing current, and tends to reduce the counter-electromotive force in the stator winding, then when operating as an induction generator, the current in the rotor will be a magnetizing current and will increase the flux, causing the counter-electromotive force to increase above the applied voltage, and the machine will become a generator supplying current to the circuit to which it is connected instead of taking power.

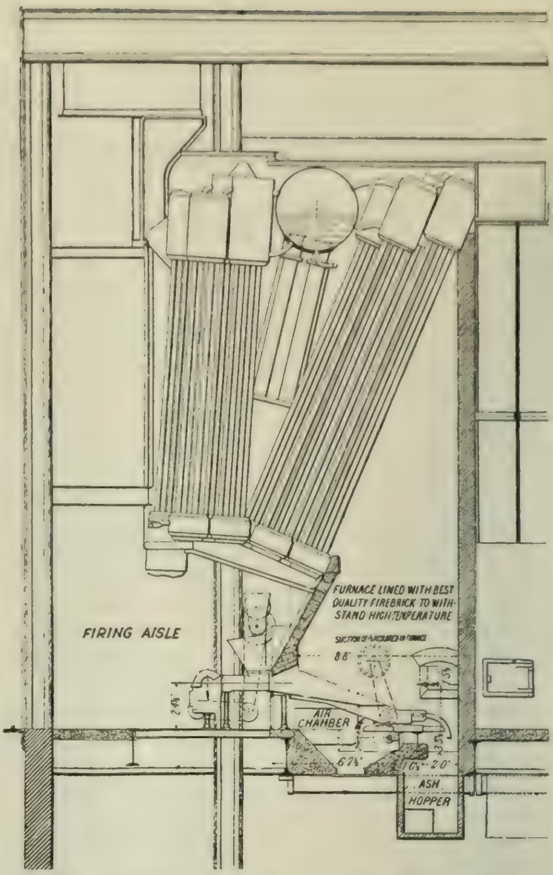
Hornsby Boilers Reset for Stokers

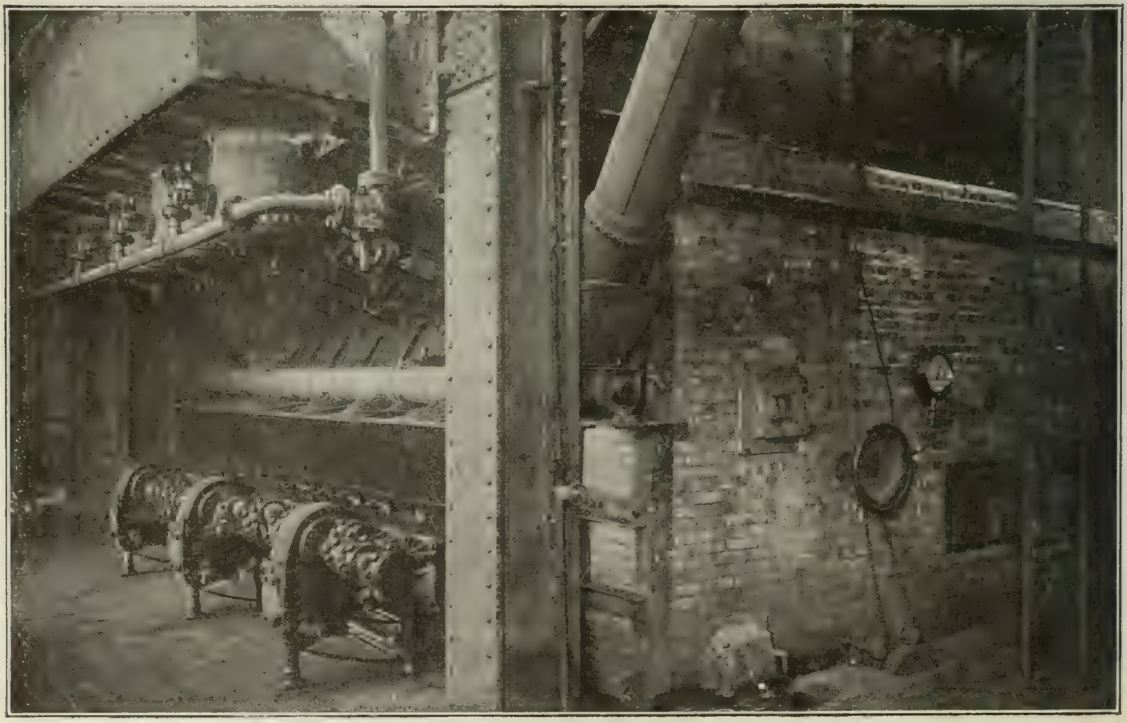
The Erith-Riley stoker has been specially developed for working in conjunction with large boiler plants installed on the unit system, and one of the latest examples is the installation of large unit stokers at the Bow Power Station of the Charing Cross, West End and City Electricity Supply Corporation, Limited, fitted to the Hornsby vertical-type water-tube boilers.

The settings and grates of these boilers were originally arranged for hand-firing; the mechanical stokers have only just been fitted, and under the present system of working each boiler is run as a separate unit. The boilers have vertical tubes with steam drums at the top and mud drums at the bottom, with the casing set back and a space in the front for the withdrawal of the tubes. Each boiler has a total heating surface of 10,850 sq.ft. and occupies about 506 sq.ft. of floor space. The steam pressure is 180 lb. per sq.in. and superheaters are included in the equipment. The rated evaporation of each boiler is 33,000 lb. of steam per hour when fired by hand, but higher duties have been obtained; in fact, a pair of the boilers has easily provided under normal working conditions the steam for one of the 4,000-kw. Sulzer-Lahmayer sets.

The halftone shows the boiler in elevation, and gives a clear idea of the general layout of the stokers and the combustion chamber. It should be noted that there is no arch in the combustion chamber, which is an important matter when high-temperature combustion is being maintained, and that the firebrick lining on the face of the combustion chamber runs straight across and, due to its inclination, had to be fixed to the casings by special means.

Each boiler is equipped with its own operating plant, which comprises an electrically driven fan for the air supply to the furnace, a variable-speed motor for driving the stoker gears, and means for regulating by hand the amount of opening of the ash plate. These, with the necessary adjuncts on the stoker gears, are provided to secure independent control of the unit and the economical working of the plant and, further, safety attachments are introduced to reduce the effect of breakages to a minimum.—*Engineering* (London), Feb. 28, 1919.


FURNACE LINED WITH BEST QUALITY FIREBRICK TO WITHSTAND HIGH TEMPERATURE
FIRING AISLE
88'
24'
AIR CHAMBER
67½'
16'
20'
ASH HOPPER

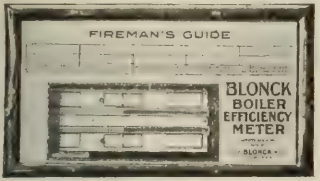


Condensed-Clipping Index of Equipment

Clip, paste on 3 x 5-in. cards and file as deired

Meter, Improved Blonck Boiler-Efficiency

W. A. Blonck & Co., Chicago, Ill.
"Power," Feb. 11, 1919

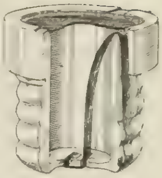


This new meter is designed so that the indicating oil columns stand one over the other for the highest efficiency of combustion. The fireman needs only to manipulate the dampers and the thickness of the fuel bed so as to maintain the columns of oil in line. When they get away from each other, the fireman simply refers to the guide printed on the face of the gage, determines what the trouble is and institutes corrective measures.

Fuse, Refillable Plug

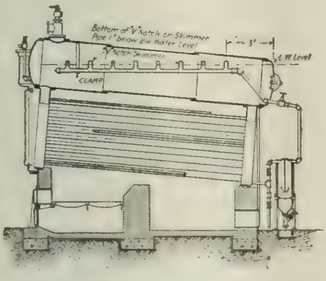
A. F. Daum, Pittsburgh, Penn.
"Power," Feb. 11, 1919

The only metal part of this refillable fuse plug is the fuse metal. The metal thread, base plug and part of the cap used in the old type non-refillable fuse have been eliminated. There are but three parts to this fuse—a porcelain base, a mica cap which can be removed and replaced to fill the fuse, and the fuse metal. Made in sizes from 3 to 30 amp., for 125 volts circuit.



Skimmer, Yarway Automatic Boiler

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn.
"Power," Feb. 4, 1919

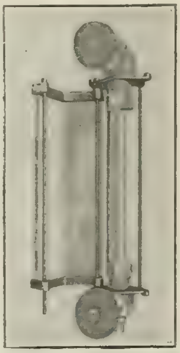


Skimmer consists of a skimmer pipe and is placed in a boiler a little below the water level. Water and scum circulate into and through a precipitator placed outside of the boiler, and in which the scum is separated from the water, which then returns to the boiler through the blowoff connection. The skimmer is designed for various types of boilers. Skimmer consists of vertical pipe made with a V-notch opening on one side and arranged to alternate.

Shield, Durable Gage-Glass

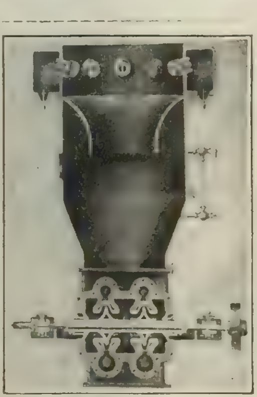
Durabla Manufacturing Co., 114-118 Liberty St., New York City
"Power," Mar. 4, 1919

Device consists essentially of two laminated glasses set in cast retainers, forming a V-shaped protector over the front of the gage-glass. Shield is hinged to water gage. Protecting plate made of laminated glass 3 in. thick, 2 in. wide, and of length varying to meet requirements. All metal parts are of brass.



Condenser, Elliott-Ehrhart Jet

Elliott Co., Pittsburgh, Penn.
"Power," Feb. 4, 1919

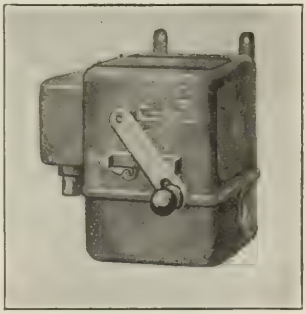


Jet condenser, vertical type Spray nozzle in condenser head breaks water into small particles so as to properly mix with the steam. Inspection openings provided in the lower surface of the overhanging condenser head. Steam ejector removes air. Centrifugal pump handles condensate.

Switch, Quick-Make Starting

Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn.
"Power," Feb. 4, 1919

Switch is designed to be used with three-phase, 220-, 440- and 550-volt squirrel-cage motor of from 2.5 to 25-hp. capacity. Starts with full line voltage. Can also be used to control feeder circuits up to 100 amp. capacity. Switch is especially suitable for shipper-rod operations. Contacts are opened and closed in oil to suppress arcing.



Thawing Outfit, Aeroil

Aeroil Coal-Thawing Outfits, Inc., 1 Broadway, New York City
"Power," Feb. 25, 1919

This thawing outfit is designed to thaw frozen coal cars, especially the hopper gates of hopper-bottom type. It consists of a 10-gal. capacity steel tank equipped with a power air pump, pressure gage, air-release valve and oil-regulating valve. Two 8-ft. lengths of hose with unions and two extension pipes with connection, also two thawing burners complete, are supplied. Outfit burns kerosene oil, rate 2 to 5 gal. per hour. It is portable.

Harrington Forced-Blast Traveling Grate

James A. Brady Foundry Co., Chicago, Ill.
"Power," Mar. 11, 1919

This is a chain-grate type of stoker and is designed for either natural or forced draft. Another feature is that the grate surface is nonsifting and grate bars slide easily over the ends of the racks. An adjustable damper controls the air pressure in the respective compartments. The closing of the damper and the removal of a door at the end of the communicating passages to the side wall, puts the stoker on its natural-draft basis. A reversal of this process converts it to a forced-draft stoker.

Patented Aug. 20, 1918

Coal Accounting in the Boiler Room*

One of the things which the war has taught us is economy, and what we learn from dire necessity is likely to be profitable. Last winter, and in fact until very recently, people had to burn less coal simply because it could not be procured readily. The problem of making a smaller amount do the same work resulted in careful examination of all possible economies, and in this effort the Fuel Administration took a prominent part.

Their very first recommendation, and of course the foundation stone of all economy, was coal accounting in the boiler room, and this is a subject deserving of attention, not only for the reasons stated, but because the stress of competition is going to require the greatest possible conservation of energy.

The simplest boiler room, of course, is hand-fired from the floor. Coal is delivered by one of several methods. Sometimes the floor is a sufficient distance below the adjacent railroad siding to allow the coal to be dumped almost to the edge of the boiler. Sometimes the coal pile is outside the plant and the fuel has to be transferred to the boiler room in wheelbarrows; and some large plants adopt this method. There have been three or four concerns in the last few years which have considered bringing coal into the plant with screw conveyors.

Then there is the little industrial car running on tracks in front of the boilers, and this, and even the wheelbarrow, can be weighed if desired. Platform scales with a flush platform have been used for years in this service, and they are improved occasionally by adding dial records.

Development of the Overhead Bunker

The inconvenience and discomfort of having coal on the floor, involving also a large item of labor, led conveyor engineers to develop the various bucket, scraper and belt conveyors with which we are all familiar. This brought about the overhead coal bunker, and immediately two schools of thought sprang up. Both were anxious to determine the amount of coal used, but the first maintained that it was sufficient to know the total quantity delivered to boiler room, while the second insisted that the consumption of each individual boiler was still more important and afforded, of course, by simple addition the other result which was desired by everybody.

With an overhead bunker, continuous in front of all the boilers, the easiest way to determine the total coal delivered to the boiler room is to weigh it as it goes into the bunker, either with a conveyor weightometer or with a large automatic scale. Sometimes, indeed, plants content themselves with taking the bill of lading of the shipper as indicative of the amount of coal received, and plants on the the waterfront will even accept the shipping weight of barges. These two plans are inaccurate, and errors as great as 8 per cent. have been found.

Plants weighing coal as it goes to the bunker sometimes have painted lines at different heights on the bunker and once a month level off the coal to these lines and so feel pretty sure that they know exactly how much coal they are using. Such determinations, however, can be only approximate and cannot give the amount of coal used in a shift of eight hours or in any time short of a month, let us say. Advocates of total coal delivered to the boiler room are better served when they do not have the overhead continuous bunker, but in its place a vertical bunker at one end of the plant, not unlike a silo. Under this the automatic scale can be placed, dumping 1000 or 2000 lb. for example, and under the scale a lorry car of one sort or another can be run and the operator can take one, two, three or four dumps of the scale as he pleases and run back to the boilers. This method will give the total coal per shift, and under certain circumstance some approximation of the individual consumption of each boiler can be obtained by keeping a careful record.

The second school of thought held that a record of the individual boiler was of prime importance. I think it fair to say that a majority of engineers today incline to this view. It seems quite reasonable that, since coal is approximately 60 per cent. of the cost of the output of a plant, it should be determined with the utmost care, but in addition to individual boiler scales, there are individual pyrometers for determining temperatures in the uptake and recording them on a chart, individual draft gages indicating uniformity of thickness of fire beds, individual CO_2 recorders showing that each fire is producing the proper percentages of the products of combustion and, lastly, the individual indicating and recording flow meter giving the steam output of each unit. Most of them have reached practical, reliable application only within the last five years.

Long before any of these accuracy devices were developed, however, and in fact as soon as overhead bunkers were put into plants, various efforts were made to determine the total coal delivered to the boiler room. Some of these were on the volumetric principle, but with them it becomes necessary to translate the cubical capacity of the container to an equivalent weight and, manifestly, this depends upon the fineness to which the coal is crushed and also upon the percentage of moisture.

Bridge Cranes and Traveling Lorries

In large central stations one frequently finds a bridge crane with a man riding around in it. He runs the crane under any desired bunker opening, puts in an unknown quantity of coal, weighs it up on a hopper scale, generally provided with a registering beam, then runs to the desired boiler and dumps the coal. What these big stations want most to know is the total coal delivered to the boiler room per shift, so they can figure out their coal per kilowatt-hour each day.

The younger brother of this big traveling crane is the traveling lorry with the suspended beam box. Frequently this is hand-propelled, and one source of error lies in the fact that the operator often pushes it along by the beam box instead of operating the chain wheel overhead, thus throwing out of adjustment the strut and tension members. These traveling lorries have many apparent advantages, however, and are frequently seen. They do not cost very much; they are portable and can always be moved aside when it is desirable to get at a boiler to clean it or pull a tube; they permit poking a slice bar up into the bunker opening in case of stoppage, and they can also be used to transport coal from one part of the bunker to a boiler at the other end of the room.

Stationary automatic boiler scales equipped with automatic counters represent a high development in the compiling of records of coal burned by individual boilers. They give a continuous record in plain figures, understandable by anybody, and hourly comparisons of coal burned with steam output can be made if desired, although the comparison of consumption on different shifts is more customary. Scales designed for continuous operation discharge coal as fast as it is taken away by the stoker and so involve no responsibility for seeing that there is ample coal to carry the station over its peak. Mounting the scales on carriages or even flanged wheels permits easy removal when it is necessary to clean boilers.

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*Abstract of a paper read by B. K. Hough, M. E., at the annual convention of the Richardson Scale Co., Jan. 3, 1919.

Utilization of the large peat areas in the north part of Jutland is receiving much attention. The area is said to be as much as 28,000 acres, which, according to *Ingeniøren*, could be completely drained by gravitation, and the total contents might be equivalent to 23 million tons of coal. It is suggested that the peat could be utilized (1) as air-dried briquets used for heating the boilers of adjacent electrical supply works; (2) as machine made briquets sold for general consumption as far away as the cost of transport will allow; (3) as peat litter to be sold to neighboring farmers; (4) the lower parts of the bogs should be reclaimed and used for agriculture. The heating value of the peat is assumed to be half that of coal. The works required should be executed by private enterprise, aided by the State, and the cost of reclamation would amount to £50,000 ($243,325). The first 9000 acres could be dealt with in twenty years, and the rest of the land occupied in course of time as the peat is cleared away.

Engineers Discuss the Oil Engine

"Adapting Fuel to the Engine versus Adapting the Engine to the Fuel" was the general topic discussed at a joint meeting of the New York local sections of the A. S. M. E. and the S. A. E. held at the Automobile Club on Wednesday evening, Apr. 9. There was an unusually large attendance, representing automobile, stationary and marine fields. Dr. Charles E. Lucke, who presided, reviewed the present oil-fuel situation and the accompanying tendencies in oil-engine design. In an effort to meet the greatly increasing demands for gasoline the producer is making every effort to extract more from the crude oil with the result that the extracted product is becoming heavier and heavier and trouble is frequently experienced with engines designed for the lighter grades. Whether the heavy-oil engine will be developed for automobile and tractor use is still an open question in the opinion of the speaker. As a solution to the use of the lower-grade gasoline, some advocated preheating the mixtures, but this, Dr. Lucke pointed out, meant less power. In the earlier hot-bulb engines he explained there seldom was complete vaporization of the oil. This led to spraying and late injection, which is now recognized as fundamental in the handling of heavy oils.

The first paper was that by J. P. Smootz, of the Bureau of Mines, who talked upon some of the problems of the chemist in an effort to keep pace with increased demands, and gave some figures of recent production.

J. H. Hunt, of the Dayton Engineering Laboratories, next told of some of the investigations there being conducted. He was of the opinion that too little coöperation exists between the oil producer and the automobile manufacturer. The former is marketing gasoline of ever-increasing density, and the latter is attempting to use it in an engine designed for the lighter grades. Much of the trouble is experienced in starting when the engine is cold. With the "choke" in, a rich mixture is drawn into the carburetor and intake manifold and is only partly vaporized, consequently particles of the heavy products are drawn into the cylinders and when an explosion takes place, cracking results. Not only does this form carbon, but the products cut the cylinder lubrication, causing excessive wear and fouling of the crank-case oil with carbon and water. Another effect of the cracking is the setting up of severe knocks, which the speaker attributed to excessive pressure or detonations rather than the commonly accepted theory of preignition. Investigations so far have indicated two remedies: First, the use of a lighter oil for starting, and second, heating the mixture. The former involves the carrying of two fuels with the attendant difficulty of securing a tight needle valve, and the second involves decreased volumetric efficiency and power.

A paper by A. H. Goldingham, of the De La Vergne Machine Co., on the heavy-oil engine was next read by the chairman. The author drew attention of the reliability of the present well-designed hot-surface type and attributed such performance to the more thorough atomization due to more efficient spraying devices and pumps, to improved construction of the vaporizing chamber, vaporizing lamp and lubrication of the parts. Engines of this type are now being made in sizes from 10 to 400 hp., the largest cylinder without piston cooling being 21 in. in diameter and 900 ft. piston speed. The cost of such engines has practically doubled since 1913. Statistics showed that of a large number of these engines in use about 42 per cent. were in pumping installations, 19 per cent. in electric-light plants and the remainder in general use.

T. O. Lisle, editor of *Motorship*, next told of some of the applications of the heavy Diesel to marine practice. He believed the Shipping Board had been remiss in not prescribing more extensive use of the Diesel engine in ships of the emergency fleet. While it was true that Diesel engines had been installed in some of the wooden ships built on the Pacific coast, this in Mr. Lisle's opinion had not been a fair trial, as the ships were in most cases underpowered and this necessitated overloading the engines continually. Also, the ships of the emergency fleet have had to deal with inexperienced labor in so far as the operation of Diesel engines is concerned, and this perhaps had much to do with some of the troubles encountered. He referred to a motor cargo ship laid down by the British Admiralty during the war, which was over 400 ft. long, had two engines with a total of 6000 hp. and designed to attain a speed of 15 knots. Sulzer Bros. had also constructed a 4000-hp. six-cylinder land engine, which is now running in France. Of eighty-six firms building Diesel engines forty-two are constructing the four-cycle, thirty-three the two-cycle and the remainder both types.

Mr. Hanson, of the Skandia Engine Co., taking part in the discussion, referred to the Diesel engines installed in the wooden ships on the Pacific coast. Numerous troubles had been encountered, he said, but these were primarily due to the wooden ships themselves. In many cases green timber had been used in their construction with the result that the bedplates had shrunk and had thrown engines out of alignment. Most of these engines had been for auxiliary power and were rated at 100 to 500 hp. each, although a full Diesel-type engine of 1000 hp. had recently been installed in one of these Pacific-built ships.

Discussing the heavy Diesel, Harte Cooke, of the McIntosh & Seymour Corp., stated that less trouble had been experienced with the very heavy fuel oils than with the lighter grades because the lighter grades contained some kerosene which would crack and result in carbon. This, however, could be rectified by arranging the fuel valve so as to have a lower temperature. With oil above 40 deg. gravity care has to be taken to avoid cracking. Oil heavier than 14 deg. is hard to handle without heating, in which case care must be taken not to throw down the lighter products. Some troubles with cylinders skipping after having been in service for several days were finally traced to the fuel-pump intake at the bottom of the oil tank. When the oil had become low in the tank, the pump had begun to draw sediment, some of which had passed through the strainer and caused trouble in the fuel valves.

Electric Drive on U. S. S. "New Mexico"

Particular interest centers around the propelling machinery of the U. S. S. "New Mexico," which has recently been commissioned and which is not only the largest and most powerful ship in the Navy, but the first battleship to be electrically driven. The following particulars are from data prepared by E. Berg, of the Turbine Engineering Department, General Electric Company.

The propelling machinery consists of two main turbo-generator units, four propelling motors, each direct-connected to a shaft, motor-driven circulating pumps, air pumps, hotwell pumps, lubricating pumps, blowers for ventilating fans and the necessary switchboard panels, etc. The total weight of this apparatus, together with spare parts, is approximately 590 tons, and the contract price, $431,000.

The main generators are two-phase two-pole 35-cycle machines, rated at 10,500 kw. at 78 per cent. maximum power factor, with an overload capacity of 25 per cent. at the same power factor, the maximum rotative speed being 2100 r.p.m. The propelling motors are of the induction type arranged for two speeds with 24- and 36-pole connections. The speed reduction between the generator and motor when using 24 poles is 12 to 1, and with the 36-pole connection 18 to 1.

The windings of the generator can be connected in multiple by means of a switch so as to reduce the voltage from 4240 to 3000, which increases the current capacity of the generator and also gives increased torque and better efficiency.

For all conditions of steady running up to about 15 knots, only one turbo-generator with the low-voltage connection is used and all of the motors connected for 36 poles. If a slightly higher speed is required, the pole connections are changed from 36 to 24, giving a speed ratio of 12 to 1 and a speed of about 17 knots, with only one generating unit. Above that speed and up to the maximum speed of the ship, over 21 knots, the second generating unit is thrown in. When both turbo-generators are in use, the high-voltage connections are employed and each serves a pair of motors, with the two circuits entirely separate.

All reversing is done with the motors connected for 36 poles. During the trial run with the boat making 21½ knots, reversal to full speed astern (two thirds of the forward speed) was attained in 20 seconds.

When operating at full load and approximately 2000 r.p.m., each generator requires 38,000 cu ft. of ventilating air per minute. The blowers are installed in a room directly above the generators; they receive air from the deck and force it through ducts into large inclosed compartments directly under the generators. After passing through the generators, the air is discharged from the top and carried upward to the deck. Each generator is served by two blowers, each capable of delivering 20,000 cu.ft. of air per minute when operating at 380 revolutions per minute.

The table shows the steam economies of the turbine. It will be noted that the official report of the board that ran the trial gives water rates somewhat higher than those guaranteed. This is explained by the fact that the water rate of a ship is not judged from the readings from electrical instruments, but is calculated from the revolutions of the propeller as previously compared with the readings of torsion meters on the shafts during standardization runs on a measured mile.

	Water Rate, Lb per Shaft Hp-Hr.			
	Full Speed	19 Knots	15 Knots	10 Knots
No. 1 Trial Report	12 29	11 926	11 667	14 223
Results indicated by readings of electrical instruments	12 30	11 55	11 35	14 35
Guarantees reduced to trial conditions..	11 67	11 03	11 495	15.28
No 2 Trial Report	12 01	12 196	12 482	14.22
Results indicated by readings of electrical instruments	11 58	11.50	11.60	14.35
Schenectady test reduced to trial conditions.	11 00	11.08	11 16	14.25
Guarantees reduced to trial conditions........	11 31	11 184	11.45	15.28

Managing director Isaacs of the Marconi Co. says that experiments in a new type of wireless telephone are so far advanced that within a few weeks it will be possible to speak between London and New York, while the establishment of a regular commercial service by wireless telephone between London and New York early next year is expected. Early realization of portable pocket wireless telephone is also foreshadowed.

Delaware Has a Board of Boiler Rules

On Apr. 8 Gov. John E. Townsend, Jr., signed a bill which had been passed unanimously by the House and Senate, providing for the safety of life and property in the State of Delaware, establishing a Board of Boiler Rules and prescribing rules and regulations for the boilers used in the state, which shall be uniform with other state rules now in existence in order to provide for the free interchange of boilers between states. The act defines the power of the Board of Boiler Rules, provides penalties for the violation of the act and the rules and regulations of the Board of Boiler Rules, and makes an appropriation for the carrying out of the provisions of the act.

The Governor is to appoint a board of five citizens of recognized knowledge in the construction and use of steam boilers, who shall act as members of a Board of Boiler Rules. These five citizens shall preferably be, one a professor of mechanical engineering, another a manufacturer who shall have been actively engaged in the manufacture of steam boilers, another a user of steam boilers, another a mechanical engineer and the fifth a licensed stationary engineer. The terms of such members shall be five years each, and they shall be so classified, but one shall be appointed each year. The rules and regulations so formulated shall be as nearly as possible in conformity with the Boiler Code of the American Society of Mechanical Engineers.

Shipping Board Lets Large Oil Contract

Contracts for 7,500,000 bbl. of fuel oil for delivery at Atlantic and gulf ports during the next twelve months, says the Washington *Post*, were awarded last week by the Shipping Board. All bids for Pacific coast delivery were rejected as unsatisfactory.

Contracts were entered into with the Standard Oil Co. of New Jersey for 3,500,000 bbl. delivered at New York, 1,500,000 bbl. at Norfolk, and 500,000 bbl. at Baltimore, and with the Standard Oil Co. of Louisiana for 2,000,000 bbl. delivered at New Orleans.

The Shipping Board in February invited bids for a total of 34,000,000 bbl. of fuel oil for the year beginning Mar. 1; the contracts just let are the first of these bids accepted.

Obituary

J. E. Johnson, Jr., mining and consulting engineer, 52 William St., New York City, died on Apr. 4 as the result of an automobile accident. Mr. Johnson was born at Long Dale, Va., in 1870. He received the degree of M. E. at Haverford College in 1891 and M. M. E. at Cornell University in 1892. He has been connected successively with the Baldwin Locomotive Works, the Straight Line Engine Co., Oswego Machine Works, Long Dale Iron Co., and Sanderson & Porter. He was a member of the American Society of Mechanical Engineers and a director of the American Institute of Mining and Metallurgical Engineers.

Personals

F. V. Sargent has been appointed by the Chicago Pneumatic Tool Co., as district manager of sales in the Boston territory, succeeding F. S. Eggleston, with headquarters at 182 High St.

First Lieut. S. A. Koenig, of the Coast Artillery, has been discharged from the Service and has joined the forces of the Advance Machinery and Supply Co., Denver, Colo., as sales engineer.

Prof. Comfort A. Adams, who is president of the American Institute of Electrical Engineers and was recently elected president of the American Welding Society, has been chosen dean of the faculty of the Harvard School of Engineering at Cambridge, Mass

Major Carlisle Mason, having resigned his commission in the United States Army, will resume the practice of general engineering in a consulting capacity at 207 Broadway, New York City, assisted by a staff of experts in the specialized branches.

Paul T. Buckler, who was formerly New York representative of the Detroit Stoker Co., and was a lieutenant in the Navy throughout the war, has returned to take up again the sale of the Detroit "V" Type Stoker in the New York territory.

Col. Peter Junkersfeld, who received his discharge from the army Mar. 4, 1919, resigned on Mar. 31 as assistant to the vice president of the Commonwealth Edison Co., Chicago, in charge of contract, operating, electrical and construction departments, to become engineering manager for Stone & Webster. For over 23 years he had been employed continuously by the Commonwealth Edison Co. and its predecessors. He was graduated from the school of electrical engineering of the University of Illinois in 1895. The postgraduate professional degree of electrical engineer from the same university was conferred upon him in 1907. When the war broke out he was one of five reserve majors who were called into service early in June, 1917, and assigned to the office of the cantonment division, which a few months later developed into the construction division of the Army. The duties to which Mr. Junkersfeld gave his principal attention were "to direct the constructing forces in the field, and to advise and direct the commercial relations of the construction division of the army." Of these five men, four remained in the service throughout the period of the war, attaining higher rank, and handling during their service construction work of almost every conceivable character in the United States, amounting to around $800,000,000. Mr. Junkersfeld entered this work with the rank of major, and attained the rank of colonel in nine months after he was called into active service.

Engineering Affairs

The Detroit Engineering Society will hold its annual meeting on Apr. 19, followed by a banquet in the evening in the Auditorium of the Detroit Board of Commerce.

American Society of Mechanical Engineers, Boston Section, will hold a meeting on the evening of Apr. 17, at the Engineers' Club, 2 Commonwealth Ave. Prof. Lionel S. Marks, of Harvard University, Consulting Engineer, Science and Research Division, Bureau of Aircraft Production, will present a paper on "Some Aircraft Projects for the 1919 Campaign." A buffet supper will be served at 6 p. m., and the meeting in the auditorium will begin at 7.30.

Business Items

Charles F. Ames & Co., Ltd., 90 West St., New York City, have been appointed to act as the New York sales department of the Platt Iron Works, of Dayton, Ohio.

The Chicago Pneumatic Tool Co. has discontinued its office at Wichita, Kan., and the stock has been transferred to the new office and warehouse at Eldorado, Kan. Another office has also been opened at 313 Richards Building, Tulsa, Okla., with warehouses at 102 North Cheyenne St.

The Sullivan Machinery Co. has recently organized a Foreign Trade Department at its headquarters in Chicago, with F. W. Copeland, who was formerly attached to the St. Louis office, as manager. This department will coördinate and assist the work of the foreign branches and agencies of the company, and will give particular attention to correspondence and inquiries from abroad.

Badenhausen Co., Philadelphia, announces the opening of additional sales offices at Pittsburgh, 311 Jenkins Building, under the management of A. D. Neeld,, Jr.; and at Chicago, 1225 Marquette Building, under the management of J. F. O. Stratton. Inquiries from their respective localities will be handled by these men.

The Wetmore Reamer Co. is the new name of the Wetmore Mechanical Laboratory Co. of Milwaukee. The company has completed all its contracts with various munition makers of Canada and this country and has resumed its tool business. More floor space has been added and the offices enlarged. P. H. Dorr, recently released from the Government service, is secretary and sales manager.

Paul W. Koch & Co., Chicago, has been organized to take over the charter of the Electrical Sales Engineers, Inc., and combine that company with Koch & Sandidge. The company will act as sole distributor of the "Jiffy" adjustable cutter, which, in the past, has been marketed by Koch & Sandidge. In addition some new patented "Jiffy" tools will be marketed. The new company will act also as Chicago district representatives of the Condit Electrical Manufacturing Co., of South Boston, Mass.; the Esterline Co., of Indianapolis, Ind.; and Lewis & Roth Corp., which lines were marketed formerly by the Electrical Sales Engineers, Inc.

The Steam Motors Co., Springfield, Mass., has appointed Raines Kessler and Louis Lanyi to transact business under the name of the Engineering Service Sales Co., as its New York representatives with offices at 8 West 40th St., for the territory comprising the eastern portion of New York State, the northeastern portion of Pennsylvania, the northern half of New Jersey, and Connecticut west of the Connecticut River. Mr. Kessler was for a number of years connected with the Terry Steam Turbine Co., being for a time its Chicago manager, and more recently has been connected with the Green Fuel Economizer Co. at New York. Mr. Lanyi has been connected with the Green Fuel Economizer Co. for several years as the chief engineer of its fan division and has specialized in the design and application of high-speed, high-efficiency blowers for use in industrial and power station work.

Trade Catalogs

Expansion Joints. Howard Iron Works, Buffalo, N. Y. Catalog X-J-2. Pages 24, 6 x 9¼ in. Describing Howard joints in the guided and semi-guided types, single and double, with and without anchor base and service outlets.

The Badenhausen Co., Philadelphia, Penn., has issued Bulletin 101, entitled "Tests," giving full details of tests on Badenhausen high-efficiency preheater type boilers installed at the Ford Motor Co's. plant in Detroit. The pamphlet should interest operators of large boiler installations where economy and low cost of operation and upkeep are appreciated. A copy may be had free upon request.

The Leeds & Northrup Co., of Philadelphia, Penn., has issued a new bulletin entitled "Checking Thermocouple Pyrometers." It discusses the importance of maintaining standards and of checking in pyrometry. It points out sources of error and the remedies for troubles in thermocouples, millivoltmeters, cold junctions and potentiometers. It outlines a commercial checking laboratory, including a special checking furnace, precision potentiometers and standardized thermocouples. It is distributed free of charge and should be in the hands of every manufacturer, the quality of whose product depends upon temperature control by pyrometric means.

The Air Reduction Sales Co., New York City, has issued the following: Booklet No. 2, entitled "How To Start Airco-Vulcan Torches and Equipment." This supplies sufficient information to make it easy for an operator to quickly and correctly connect up these torches and regulators, and to operate them properly. Booklet No. 3, entitled "An Airco Achievement—Reclaiming Railroad Frogs by the Oxyacetylene Process." This describes the oxyacetylene process of welding and cutting metals and shows evidences of the success of the method of making repairs in some of the railroads of the country. Three leaflets issued also by the company are: "Airco Acetylene Generators," "Built Up Rail Frogs," and "Airco Service."

THE COAL MARKET

BOSTON—Current prices per gross ton f.o b New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.35
Philadelphia, gross tons	4.20@4.90	5.00@5.40
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.65

Pocahontas and New River are quoted at $4.70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5.95	$7.80	Pea	4.80	6.55
Egg	5.85	7.70	Buckwheat	3.40	5.15
Stove	6.10	7.95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.80 @ 3.10	2.95 @ 3.25
Clearfield County	2.65 @ 2.95	
Reynoldsville	2.65 @ 2.85	2.85 @ 2.95
Quemahoning	2.85 @ 3.10	2.95 @ 3.10
Somerset County (best grades)	2.75 @ 2.95	2.95 @ 3.10
Somerset County (poorer grades)	2.40 @ 2.75	2.75 @ 2.95
Western Maryland	2.50 @ 2.75	2.65 @ 2.85
Fairmont	2.10 @ 2.35	2.35 @ 2.50
Latrobe	2.10 @ 2.25	....
Greensburg	2.35 @ 2.40	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6.10	7.95	Boiler	2.50	3.50
Nut	6.20	8.05	Barley	2.25	3.15
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.87@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

		Mt. Olive and Staunton	Standard
Franklin County			
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2.30	...
2-in. lump	....	....	2.15

Williamson-Franklin rate to St. Louis is $1.07½ other rates 92½c.

New Construction

PROPOSED WORK

Mass., Dorchester—The Upham Market Co. will install a steam heating plant, refrigerating machines and conveyers in the 2 story, 84x117 ft. market which it plans to build on Ramsey St. Total estimated cost, $100,000. W. M. Bacon, 27 Kilby St., Boston, Arch.

Mass., Worcester—Higgins & Fitzgerald, 840 Main St., will install a steam heating plant and vacuum cleaning system in the 3 story, 40x125 ft. apartment hotel which they plan to build on West Elm St. Total estimated cost, $125,000.

Conn., New Haven—The Chapel Street Ecclesiastical Society, Whitney St., will install a steam heating plant in the 2 story, 76x130 ft. parish house which it plans to build. Total estimated cost, $100,000. W. S. Cady, 40 West 32nd St., New York City, Arch.

Conn., Stamford—C. E. Slawson, Canal St., will install a steam heating plant in the 3 story, 128x150 ft. grain warehouse which it plans to build. Total estimated cost, $150,000. Thompson-Binger, 280 Madison Ave., New York City, Engr.

N. Y., Brooklyn—A. Stockhammer, 1368 St. Johns Place, will install a steam heating plant in the 2 story, 100x120 ft. theatre which it plans to build on St. Johns Place and Schenectady Ave. Total estimated cost, $150,000. Carlson & Wiseman, 226 Henry St., Engr.

N. Y., Clark Mills—The Adirondack Electric Power Corp., Union Sta., Utica, plans to build a 16 mi. transmission line from its substation here to one at Oneida, thereby connecting company's Oneida and Canastota plants with a high tension line.

N. Y., Norwich—R. F. Chaffee is in the market for complete ice plant equipment, to include compressor, freezing tank, can moulds and power plant; preferably oil engine drive. Plant to have capacity of 20 tons ice per day and little additional refrigeration to take care of 4800 cu.ft. ice storage space.

N. Y., Rensselaer—W. S. Clark, c/o the Board of Education, will receive bids for installing a steam heating boiler in P. S. No. 2. Estimated cost, $1,500.

N. Y., St. Johnsville—The Dolgeville Felt Shoe Co., Little Falls, has taken over the Englehardt factory here and will install power and transmission machinery for the manufacture of felt shoes and slippers. Address I. E. Stacey, 28 Waverly Place, Little Falls.

N. J., Toms River—The New Jersey Public Utilities Commission has ordered the Ocean County Gas Co. to build additions to its plant here. Plans include the installation of an additional generating unit and a larger steam boiler.

Va., Norfolk—R. E. Sparks, St. George Hotel, is in the market for an electrical welding machine, motor generator and switchboard. Would like to receive catalogues and prices on same.

Fla., Miami—The East Coast Cattle Co., 1425 Ave. D, plans to build a cold storage plant here.

Fla., Miami—The Miami Electric Light & Power Co., 12th and Court St., plan to enlarge its plant. Estimated cost, $200,000. H. H. Hyman, Mgr.

La., New Orleans—The New Orleans Petroleum Co., Woolworth Bldg., New York City, will install turbine generators in the oil refinery which it plans to build 15 mi. from here. Total estimated cost, $1,500,000. Work will be done by day labor.

Tenn., Harriman—The city is in the market for a center crank, self contained, high speed engine of from 200-250 h.p. (Ideal or Skinner, preferred) and for this engine one 2300 V, 3 phase, 60 cycle, generator or direct connected unit of the same size. R. C. Walzi, Supt. of Water Wks.

Ohio, Cleveland—The Aluminum Castings Co., 2800 Howard Ave., plans to build a power house on Howard Ave. and East 28th St. Estimated cost, $50,000. G. S. Rider Co., 612 Century Bldg., Arch.

Ohio, Cleveland—O. P. Brown, 304 East St., New Castle, Penn., W. M. Brown Estate, will install a steam heating plant in the 10 story mercantile building which he plans to build at 1110 Superior Ave. Total estimated cost, $100,000.

Ohio, Cleveland—The Clark Manufacturing Co., East 38th St. and Perkins Ave., will install a steam heating plant in the 3 story, 100x144 ft. addition to its factory. Total estimated cost, $100,000. H. E. Shimmin, 2053 Euclid Ave., Engr.

Ohio, Cleveland—I. M. & L. A. Osborne Co., Superior Viaduct, will install a steam heating plant in the 4 story warehouse which it plans to build on Superior Ave. and East [illegible] St. Total estimated cost, $60,000. G. S. Rider Co., 612 Century Bldg., Arch.

Ohio, Newark—W. S. Wescott & Son plans to build a 1000 h.p. boiler plant, also to change 50,000 ft. hot water radiation to vacuum steam, and is in the market for 1 [illegible] turbine generator set of about 500 kw., 440 volts, [illegible] cycle, also feed water heater, vacuum pumps and boiler feed pumps.

Ind., South Bend—The Studebaker Corp., Brush and Piquette St., Detroit, Mich., plans to build a 4 story factory here. Plans include the construction of a power house, [illegible]. Total estimated cost, $[illegible]. W. F. Wollering, 1st Vice Pres.

Ill., Chicago—I. Blum, 919 Fulton St., will install a [illegible] h.p. motor and [illegible] ton ice machine in the [illegible] story, 40x118 ft. meat products plant which he plans to build at 912 Fulton St. Total estimated cost, $80,000. G. H. Grussing, 154 West Randolph St., Arch.

Ill., Chicago—The Brighton Theatre Co., c/o A. L. Levy, Arch., 28 North Clark, St., will install a steam heating plant in the 2 story, 100x160 ft. theatre and office building which it plans to build on Archer Ave. and Sacramento Blvd. Total estimated cost, $235,000.

Ill., Chicago—The Melville Clark Piano Co., 25 East Jackson St., will install a 300 hp. high pressure boiler in the factory which it plans to build on Kedzie Ave. and 48th St. Total estimated cost, $400,000. Mundie & Jensen, 39 South La Salle St., Arch.

Ill., Chicago—The South Chicago Savings Bank, 3017 East 92nd St., will install a steam heating plant in the 4 story, 55x160 ft. bank, store and offices which it plans to build on 92nd St. and Commercial Ave. Total estimated cost, $200,000. Ivar Viehe-Naess, 64 East Van Buren St., Arch.

Ill., Columbia—The city will soon receive bids for installing boilers, chimney, engine, and generator, switchboard, steam specialties piping etc., in the electric light and power plant. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Ill., East St. Louis—Swift & Co., National Stockyards, will build a 500 ton. 22x48 ft. ice machine. Estimated cost, $114,000. T. P. Middleton, c/o owner, Engr. Owner will build by day labor.

Ill., Elmhurst—The Board of Education will install a steam heating plant in the 2 story, 152x168 ft. high school which it plans to build here. Total estimated cost, $125,000. J. C. Llewellyn, 38 South Dearborn St., Chicago, Arch.

Wis., Sheboygan—R. C. Clark, Arch., Builders Exchange Bldg., Chicago, Ill., will receive bids about May 1 for the construction of a 1 story, 40x250 ft. cooler room on South Water St., for Armour & Co. Estimated cost, $22,000.

Neb., Lincoln—T. H. Berg, City Clk., will receive bids until April 30 for furnishing and erecting oil engine and generator direct connected, about 300 kw., 80% p.f., 60 cycle, 3 ph., 1100 v., exciter, oil and air piping, exhaust muffler, etc. Estimated cost $50,000. A. Dobson, City Engr. Noted Apr. 1.

S. D., Madison—The city plans election soon to vote on $125,000 bonds for rebuilding the electric light and power house recently destroyed by fire.

S. D., Sioux Falls—The Northern States Power Co. plans to enlarge and improve its plant. Plans include the installation of a 3,000 kw., steam turbine and complete rebuilding of the power distribution system. Estimated cost, $500,000. N. C. Draper, Mgr.

Mont., Livingston—R. C. Fuhrman is back of a movement to form a stock company to construct and operate a 20-ton artificial ice plant. Estimated cost, $20,000.

Mo., Joplin—The Y. M. C. A. will install a steam heating plant, motors, boilers and engine in the 5 story, 103x129 ft. building which it plans to build on 5th Ave. and Wall St. Total estimated cost, $209,627. Smith Rea & Lovitt, Frisco Bldg., Arch.

Mo., St. Louis—The Mineral Refining & Chemical Corp., Iron Mountain tracks and Des Pere River, will require power equipment in building an addition to its plant and pigment plant. Total estimated cost, $500,000. A. E. F. Versen, c/o the owner, Engr.

Colo., Stoneham—The city plans election soon to vote on $40,000 bond issue for the construction of a light plant and waterworks system.

Cal., Corcoran—The Corcoran Irrigation District will petition the Bd. of Supervs. Kings Co., Hanford, for authorization to form irrigation district. Plans include the construction of dams, reservoirs, canals, wells, and the installation of pumps, etc.

Cal., Los Angeles—J. P. Vroman, Sec'y., Bd. of Pub. Wks., 645 South Olive St., will soon award the contract for furnishing distribution transformers for the light and power system. E. F. Scattergood, Ch. Electr. Engr.

Que., Chicoutimi—The Saguenay Power Co. has been incorporated with $3,000,000 capital, by A. Lemieux, 107 St. James St., and others, for constructing and exploiting hydraulic gas and electric workshops and the distribution of electricity, gas, etc.

Que., Donnacona—The Donnacona Paper Co. has purchased 183,360 acres of timber land on the Jaques Cartier River 27 mi. from Quebec and plans development; to include dam, flume, power house and installing electric generating equipment. G. H. P. Gould, Lyons Falls, N. Y., Pres.

Que., Quebec—The Marine Department, Ottawa, Ont., will require 2 boilers for the Canadian Government Steamer "Montcalm". Estimated cost, $70,000. F. Macdonnell, Engr.

Que., Verdun—The city plans to build extensoins to the water and electric plant. Estimated cost, $150,000. A. E. Cohy Sons, City Hall, Engr.

Ont., London—J. & J. J. Allen will install complete steam heating equipment in the theater, store and office building which it plans to build on Dundas St. Total estimated cost, $200,000. C. H. Crane & E. G. Kiehler, 2334 Dime Bank Bldg., Detroit, Mich., Arch.

CONTRACTS AWARDED

N. Y., Buffalo—The Board of Education received bids for installing heating and ventilating systems in P. S. No. [illegible], from H. J. Wood & Co., 1358 Main St., $50,949; electrical work, from the Buffalo Electrical Construction Co., 18 Bway., $7,500.

N. Y., New York—The Board of Education received bids for installing heating and ventilating apparatus in P. S. 40, from D. J. Rice, 42nd St. and Lexington Ave., $62,173; Gillis & Geoghegan, 537 West Bway., $66,478; Teran, Mahoney, Monroe, Grand Central Terminal, $67,300.

N. Y., Whitesboro—The Board of Education has awarded the contract for installing a heating and ventilating system and electric equipment in the high school building here, to the P. W. Schneider Co. Inc., 16 Pearl St., Utica, $17,210, and to the J. & M. Electric Co., 26 Bank St., Utica, $3,900 respectively.

Md., Towson—The St. Vincent's Male Orphan Asylum, York Rd., received lowest bid for altering existing buildings and constructing a 1 story, 40x50 ft. boiler house, from J. J. O'Connor, 52 Knickerbocker Bldg., Baltimore. Estimated cost, $50,000.

Mich., Detroit—The Board of Water Commissioners, 232 Jefferson Ave., has awarded the contract for the construction of a 1 story, 54x90 ft. boiler house and steel coal hoppers, to Lennane Bros., Union Trust Bldg. and F. E. Chapper Iron Works, 128 Fort St., E.; $27,238.

Mich., Wyandotte—The city has awarded the contract for furnishing and installing 2 low lift, motor driven centrifugal pumping units 2100 and 4200 gallons per minute, also steam driven pumping unit, 5,000,000 gallon capacity, horizontal cross compound crank and fly wheel pumping engine, to the Platt Iron Works, Arrott Bldg., Pittsburg, Penn. Estimated cost, $12,000. Noted Feb. 26.

Ill., Chicago—The Eagle Ice Co., 4946 Federal St., has awarded the contract for the construction of a 2 story, 70x175 ft. ice factory, to A. C. Wehrwein, 6428 Vernon Ave. Estimated cost, $20,000. E. G. McClellan, 38 South Dearborn St., Arch.

Minn., Hibbing—The Hibbing Power & Light Department has awarded the contract for the construction of a 3 story, 100x160 ft. power house on 6th Ave. and Wilson St., to the National Electric Construction Co., St. Paul; full battery of electric dynamos, water generators, boilers and electrical equipment will be installed in same. Total estimated cost, $700,959. Noted Jan. 7.

Neb., Omaha—The Higgins Packing Co., 1215 Woodmen of the World Bldg., has awarded the contract for the construction of the first unit of the cold storage plant, 4 story, 50x100 ft. on 36th and L St., to J. Hansen, 803 Ave. F, Council Bluffs, Ia. Estimated cost, $70,000.

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See pages 87 to 96

POWER

Volume 49 New York, April 22, 1919 *Number* 16

The Infinite and the Infinitesimal

By JOS. W. HAYS

It has been said that we Americans like to do things in a big way. We do and we brag about it. We produce and consume upon an enormous scale and we waste out of all reasonable proportion to our consumption.

We are mining coal in the United States at the rate of more than 600,000,000 tons per annum. A few tons more or less are nothing to us. Just call it an even 600,000,000.

We needlessly and heedlessly waste a quarter of all the coal we produce, or 150,000,000 tons per annum. This is an understatement of the waste rather than an overstatement. Engineers who have studied fuel waste in hundreds of plants, big and little, agree that we waste a quarter of all that we produce. Some of it is wasted in handling and storage. Most of it is wasted in burning.

Visualize 150,000,000 tons of coal if you can.

Loaded on coal cars, 40 tons to the car, it would make a train 28,407 miles long, not counting the caboose at the tail end of it. Think of a train of loaded coal cars girdling the earth with a lap over of more than 3000 miles! As you think of it, perhaps you will remember the coal famine and the heatless days of the winter of 1918.

The engine of that train would travel 275 miles before taking the "slack" out of the couplers and starting the caboose.

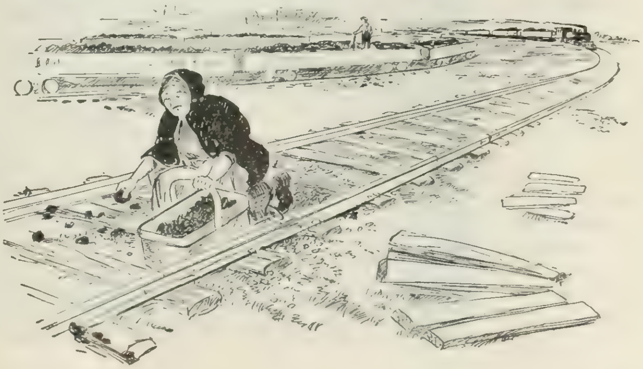
What is 150,000,000 tons of coal worth at the present time, figuring the average "delivered" price per ton paid by the industrial and domestic consumer? Nobody knows, of course, but it must be more than $5. Call it $5, and the wasted coal represents a sum of money sufficient to pay the yearly interest on all of our Liberty Bonds AND THEN SOME.

Looking from the window of a comfortable Pullman, I saw an old woman, with a shawl over her head, picking coal out of the ice and snow in the railroad yards of a big terminal. She was salvaging an infinitesimal fraction of the infinite waste—risking her life among the moving trains for a basketful of coal.

The sight struck me as pitiful and the waste strikes me as criminal.

The coal we are wasting does not belong to us. It is a part of the natural wealth of our country rightly belonging to future generations. We are wasting something given to us in trust and we are guilty of "larceny as bailee." I think I know what posterity will say about us, but I won't tell you because I don't use that kind of language.

WHAT ARE YOU AND I AND THE REST OF US GOING TO DO ABOUT IT?



The Clinker Grinder in Modern Boiler Practice

By CHARLES H. BROMLEY

Deals with the development and application of the clinker grinder. The article shows many of the grinders installed in various power stations and gives performance data of these grinders.

NOT long after the installation of the large Stirling boilers in the Delray Station of the Detroit Edison Co., I watched the men break the huge clinker that accumulated on the dump plate of the stokers under these now famous boilers. Here in this plant was the epitome of modern boiler-room practice. In capacity an extraordinary boiler. There were so many eggs in one basket that everybody in the profession anxiously watched and waited to see how well Alex. Dow was going to carry it now that he had it. Well, he is carrying it yet, and has since put several more in another—the Connors Creek Station.

But the men with the long, heavy bar breaking clinkers—the situation was like walking on all fours up Fifth Avenue amid Packards and Pierce Arrows, like a tom-tom accompaniment to Galli-Curci. This is not said disparagingly.

This excellent piece of coal-burning apparatus had not yet "arrived" despite its excellence. The mechanical clinker grinder or rotary ash discharge had to come to first eliminate the burden imposed upon human muscle in the removal of ash and clinker from the furnace—this is its chief function—to help maintain a shape of fuel bed that would give more complete combustion, and to continuously or intermittently break up and agitate the clinker that the carbon imprisoned in the mass might be made to give up its heat for steam production instead of being dumped, sometimes in appreciably large amounts, into the ashpit; and last, to discharge the ash in such condition that it could be handled by any form of conveyor. These are now accomplished.

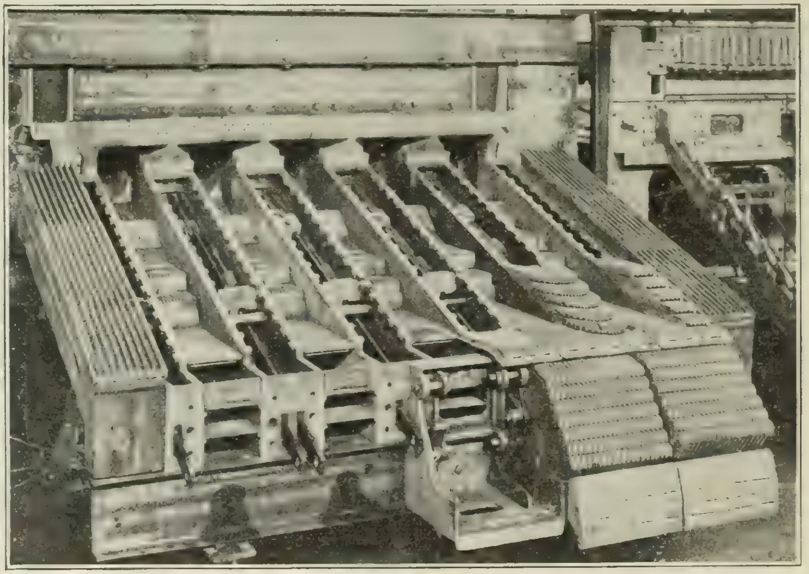


FIG. 1. SHOWING TWO SECTIONS (RIGHT) OF THE OVERFEED GRATES WHICH FORM ONE SIDE OF THE WESTINGHOUSE GRINDER

But the reader should have in mind that modern clinker grinders are intended for the exceptional rather than for the usual plant. In large stations where the labor is highly competent, reliable and attentive, they will be a success. Where these conditions do not exist, and for the average power plant, they are better out than in, as the ordinary dump plate will serve the purpose just as well. Penalty for abuse and negligence of the clinker grinder will be heavy.

It is very desirable that a boiler give high combined efficiency over a wide range in capacity, regardless, in a measure, of how much combustible there is in the ash. That is, one must not supply so much air to burn out a little carbon in the ash or agitated clinker that the combined boiler and furnace efficiency suffers due to this excess air. Load conditions for the usual central station demand a boiler rating of about 250 per cent. on peaks. Some stations go higher. A stoker may be made to feed coal so fast that it will not completely burn the fuel as rapidly as it is fed. A lot of coke gets down on the dump plate or dump grate, embedded in clinker so badly that air for combustion, even if the dump plate has air openings, cannot advantageously reach it and it is dumped into the ashpit. This is what happens on peak loads. How serious will be the loss of carbon to the ashpit obviously depends in great measure upon how fast the coal is fed—upon the boiler rating, for boilers not inordinately overstokered and with stokers having no clinker grinders or positive agitation of the clinker. The loss may be said to average about 25 per cent. in most plants, going on occasions to 50 per cent. The loss here referred to means that 25 or 50 per cent. of the total amount of "ash" is combustible. During the period of coal shortage, when everybody was gratified to get coal of any quality, the loss of carbon to the ashpit was higher than usual, supporting the belief that the amount of incombustible in the coal influences this loss, increasing it with increase in incombustible.

The clinker grinder is not new. It has these many years been used with Murphy stokers. Its function is to mechanically remove clinkers from the furnace. The chief function of the clinker grinders of today is the same; but designers aim also to quite completely burn the combustible in the ash and clinker before the latter drop deep into the clinker pit of the grinder; that is, by extending the grate surface, at the refuse end of the stoker making it movable to agitate the clinker, and by providing air admission at both sides of the top of the clinker pit. The tendency is toward deeper clinker pits to insure that the clinker, when it gets to the rolls or grinder, will be cool to avoid damaging the grinder.

The perforated dump plate, or grate, Fig. 11, as it may be called because it is active grate area, bears relation to the modern clinker-grinder development. As grate surface it is not so active as active surface farther up on the stoker, but it does assist materially in burning out the carbon after the clinker there is broken and agitated either by hand or by the reciprocating overfeed section of the stoker, where such is provided.

The desirability of controlled air admission to the refuse end of the stoker is incontrovertible. But it is obvious that grate openings or dampers alone do not control, since the resistance through the fuel bed may be still more important. Some of the first Roney stokers had dump grates with slotted holes. When the upper part of the fuel bed became heavy, as when low-ash coals were used, large quantities of excess air, following the path of least resistance, went through these openings; in fact, this trouble was so serious that the builders blanked the dump grates.

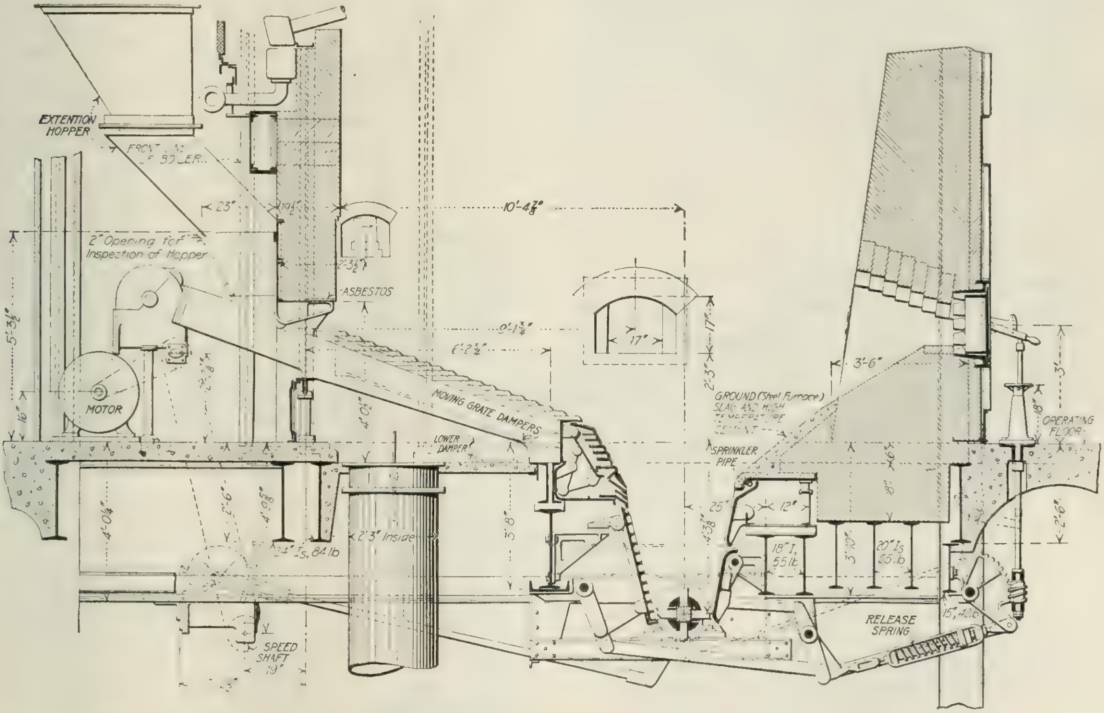


FIG. 2. EDISON ELECTRIC ILLUMINATING CO., BOSTON. CLINKER GRINDER UNDER LATEST SETTING FOR CROSS-DRUM BOILER, WESTINGHOUSE UNDERFEED STOKER. SPRINKLER PIPE USED INSTEAD OF WATERBACK

Where the air to the lower, or refuse, end of the stoker is controlled, some excellent results have been had in burning carbon from the ash. At the Union Gas and Electric Co., St. Louis, tests on a double-dump-grate Westinghouse underfood stoker without clinker grinder gave the results shown in Table I.

Notice that the ash in the coal runs from 16 to 22 per cent.

Where there is no means of sufficiently increasing the air supply to the coking grate or to the extension or dump grate, in relation to the rapidity of feeding coal, a loss results due to insufficient air—that is, to carbon monoxide—because combustible piles upon these grates faster than the grate is able to burn it. The figures of Victor Phillips[1] relative to operation in the Cleveland Railways Co.'s plant are interesting enough to refresh one's mind of the usual magnitude of such loss:

TABLE I. RESULTS OF TESTS ON DOUBLE-DUMP-GRATE UNDERFEED STOKER

Per Cent Boiler Rating	Per Cent. Combustible in the Ash	Per Cent. Ash in the Coal
169.7	18.0	15.9
154.0	11.5	18.3
217.65	....	19.8
153.78	9.5	18.2
174.5	7.5	18.38
176.0	11.5	22.2
165.0	14.0	20.7
159.0	23.0	20.7
170.0	16.0	20.7
164.0	14.0	20.4
170.0	11.2	20.5
189.6	15.0	19.9
178.0	15.0	18.2
116.0	14.0	20.2

Fuel Bed Thickness	Thick			Medium			Thick		
Horsepower output of boiler	452	661	895	500	736	923	504	718	902
Ash in coal, per cent	13.2	12.4	12.6	12.4	11.8	11.6	12.5	12.5	13.2
Combustible in ash, per cent	5.1	4.0	7.6	4.6	10.0	7.0	17.3	17.3	20.0
CO loss	0.4	0.8	10.9	6.6	11.2	13.9	14.8	11.4	

Many tests with a Westinghouse stoker having air admission to the dump grate at one of the Detroit Edison Co.'s stations gave an average of 12 per cent. carbon in the ash. Though I have no figures as to the average boiler rating during these tests, the ratings were all under 200 per cent. and the ash in the coal was less than that in the coal used in the Union Gas and Electric Co.'s tests at St. Louis, where the average carbon in the ash was 13.86 per cent. But the figures serve well when contrasted with tests reported by the University of Illinois on Illinois coal in which the carbon in the ash is from 17 to 40 per cent.

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[1] "Relation of Boiler Efficiency to Capacity," presented before the American Society of Mechanical Engineers, Cincinnati, Ohio, May, 1917. Power, July 31, 1917.

Before taking up specific installations it is advisable to consider the chief things which experience with grinders has taught those who design and those who operate them. As the Murphy grinder is the oldest, the following, from a communication by George I. Bouton, chief engineer of the Murphy Iron Works, is of value.

The disposal of the refuse on a stoker has probably caused more heartaches than any other part of the stoker design. The various stoker builders are continually hunting for some satisfactory means of disposing of the refuse. This was apparently one of the principal problems which confronted Thomas Murphy, and we find it a prominent part of his first patent, dated Nov. 9, 1875, which covers among other things, his revolving-toothed cylinders. In his description he writes in part as follows: "Also, to so arrange the grate bars that every second one may be vibrated to free the grate from ashes and to collect the clinkers and refuse at certain points where they can be removed, or ground up and then removed by toothed cylinders rotated by cranks on the outside of the furnace."

In its original form it was apparently a solid casting. About 1895 the use of steam in connection with the clinker grinders appears, and this is covered by a patent of John H. Nicholson, Oct. 8, 1895. The use of the hollow air-cooled clinker grinder which was connected [by a duct] to the rear end of the flue beyond the boiler damper appeared about 1897.

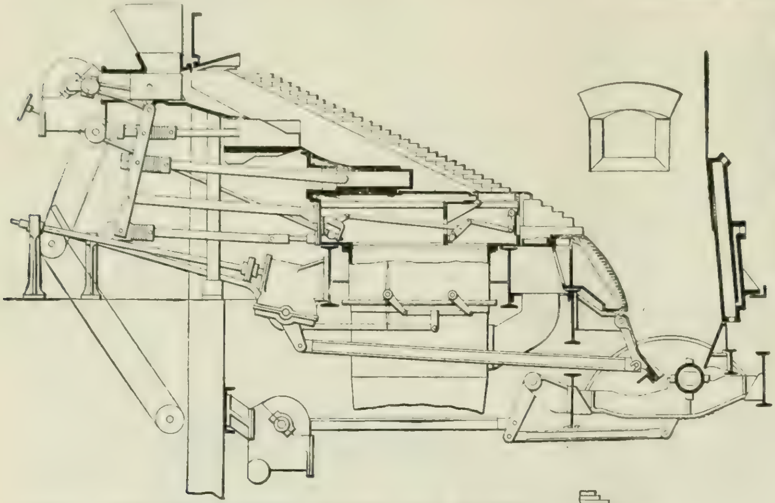


FIG. 3. STANDARD CLINKER GRINDER AND WATER-COOLED BRIDGE-WALL OF THE AMERICAN ENGINEERING CO.

The clinker grinders were cast around a hollow tube or piece of pipe, beginning about 1895. The rear end of the clinker grinder was connected to the flue behind the outlet damper, air being admitted to the front, the idea being that this would keep the clinker grinder cool. A pipe was cast into each side of the grate bearer, and this pipe was provided with a series of holes which were drilled through from the outside. These two lines supplied steam to the clinker grinder and also supplied steam under the lower ends of the grates.

As the stokers got larger, the need for a sectional form of clinker grinder and a sectional form of grate bearer became urgent, and these were developed in the latter part of 1907 or the early part of 1908. The original sectional clinker grinder was made up of 2-in. two-toothed sections strung on a square shaft. A single steam line was placed under the center line of the clinker grinder, but Mr. Fortune, in his patent of Oct. 16, 1909, indicated that additional steam lines might be placed to supply steam under the lower end of the grates. The single steam line was adequate for the coals that were reaching the market at that time. The square bar tended to twist, however, and repairs were difficult, and the final move was to make the bar a round bar, doing the driving through the clinker grinder sections. At the time these sectional interlocking clinker grinders were being developed, the matter of cutting down the capacity of the clinker grinder seemed to be of considerable importance, and one of the early forms of the clinker grinder had a 7-in. body with a total of 9 in. over the teeth; that is, teeth projecting 1 in. from the body. Later, this was changed to a 6½-in. and then 6¼-in. body with 8½-in. over the teeth, and this is our present standard interlocking clinker grinder for the 12-in. grate bearer.

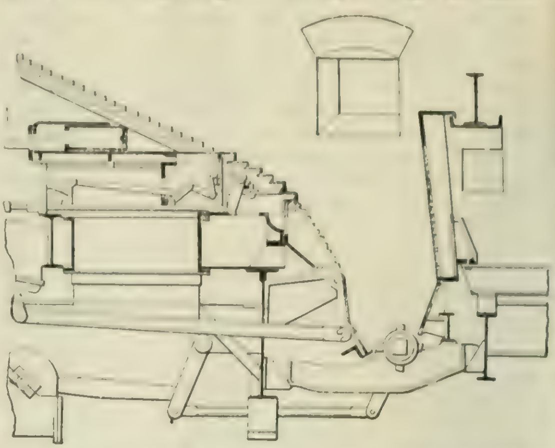


FIG. 1. PUBLIC SERVICE ELECTRIC CO., ESSEX STATION, NEWARK, N. J., AIR-COOLED BRIDGE-WALL

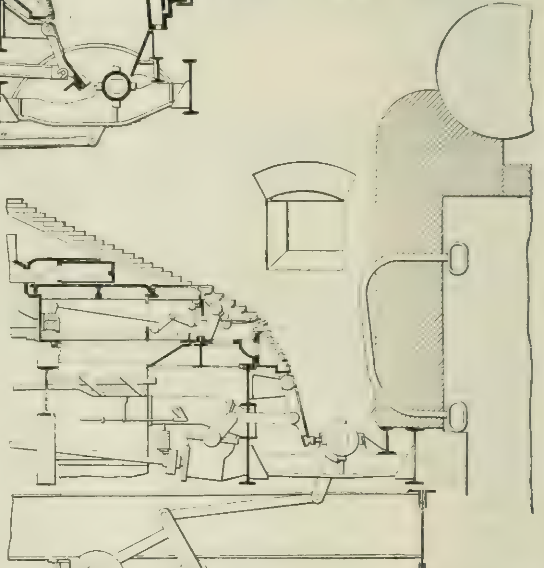


FIG. 5. FORD MOTOR CO., DETROIT; HIGH-PRESSURE WATER-COOLED ROTARY ASH DISCHARGE, TAYLOR STOKER

The tendency with the single clinker grinder was to pile up clinker on the side toward which it ground, while the side from which it ground was likely to be inadequately protected with ash or clinker. On the larger stokers, however, it was difficult to get sufficient strength for these small double clinker grinders, and shortly after the writer took charge as chief engineer, we reached an agreement in the engineering department that we would not furnish double clinker grinders on a 12-in. bearer for stokers more than 6 ft. deep.

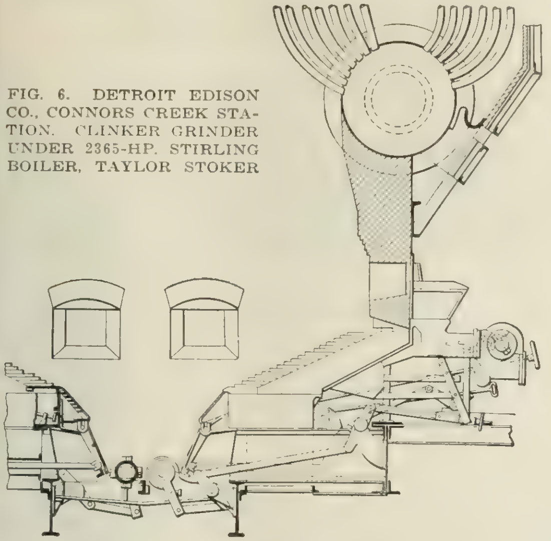


FIG. 6. DETROIT EDISON CO., CONNORS CREEK STATION. CLINKER GRINDER UNDER 2365-HP. STIRLING BOILER, TAYLOR STOKER

To meet the demand for a double clinker grinder for the large stokers, we designed, about four years ago, the 18 in. grate bearer with the two large interlocking clinker grinders. These worked fine on the first installation, which happened to be a coal with ash of high fusing temperature. When we struck ash of a low fusing temperature, however, our troubles began, as the original clinker grinders of this design were equipped with but one steam line, the old practice of the Murphy company being a single steam line midway and slightly below the clinker grinders. This steam line tended to block the free passage from the clinker grinders, and it was removed and a single line under the center of each grinder substituted. This is our present standard practice for these clinker grinders.

Later, to insure the clinker reaching the clinker grinders, we installed steam lines under the lower ends of the grates, which, as already stated, is simply a reversion in type. It does not make any difference how effective the clinker- and ash-removal equipment on a stoker may be, it is absolutely useless unless the clinker and ash reach the refuse-removing device. In other words, if the ash is of low fusing temperature and melts in the upper sections of the stoker, the refuse-removing device is practically useless. The result is little clinker and a large amount of coke in the refuse. For this reason we consider it desirable to use steam under the lower ends of the grates where ash of low fusing temperature is encountered, and stokers going into a territory where we expect to meet this condition are equipped with these steam lines. They are valved so that they can be used or not, as desired.

If, with a coal running 15 per cent. laboratory ash, we get refuse that runs 60 per cent. combustible, a condition which is found on some stokers, the combustible in the ash amounts to 22½ per cent. of the total coal, or about 26½ per cent. of the heat value of the coal. If this combustible in the ash, with the use of additional steam, can be reduced to 20 per cent., a figure which is not at all impossible, the combustible in the ash represents 3¾ per cent. of the coal, or about 4.4 per cent. of the heat value of the coal. In other words, 22.1 per cent. of the heat value of the coal is saved. If it takes 3 per cent., 4 per cent. or 5 per cent. of the steam produced by the boiler to make this saving, the investment is evidently a good one, and so far as the writer has been able to find out, 3 per cent. or 4 per cent. of the steam produced by the boiler will kill the clinker in any coal we are likely to meet.

According to our present standards, we use 8-in. grate bearers and small single interlocking clinker grinders on stokers 6½ ft. wide and smaller. We use 12-in. grate bearers and large single interlocking clinker grinders on stokers 7 ft. wide and larger. We use 18-in. grate bearers and large double interlocking clinker grinders on stokers where the local conditions seem to make their use advisable. These are seldom used, however, on stokers less than 8 ft. wide, though we have used them on the 7 x 6-ft. stokers at the Blackstone Hotel and the 6 x 5-ft. stokers at Oglesby. The coal at Oglesby was about as bad as one is likely to find so far as the ash content is concerned. The laboratory ash ran 25½ per cent. The ash was plastic at 1976 deg. F. and fused at 2120 deg. F. It was quite an impossible situation until more steam was added under the grates and under the clinker grinders.

All clinker grinders have steam lines directly below them. This means that there is one steam line where single clinker grinders are used and two where double clinker grinders are used. Steam lines are provided under the lower ends of the grates on stokers which are to burn Ohio, Indiana, Illinois or Michigan coal.

Some typical performance figures of the Murphy grinder follow:

PERFORMANCE OF MURPHY FURNACES

Rated Horsepower of Boiler	Per Cent. Rating of Boiler	Combined Efficiency, Per Cent.	B.t.u. Coal as Fired	Per Cent. Ash in Coal	Per Cent. Combustible in Ash
253 8	134 35	80 34	12,130	14.97	14 86
253 8	159.3	76.28	13,217	11.81	12.19
143 1	119.0	73.58	13,318 Dry Coal	12.64	16.87
143 1	172 66	74 84	12,672 Dry Coal	16.43	17.19

In developing the grinders now being applied to underfeed stokers the designers of the Taylor stoker

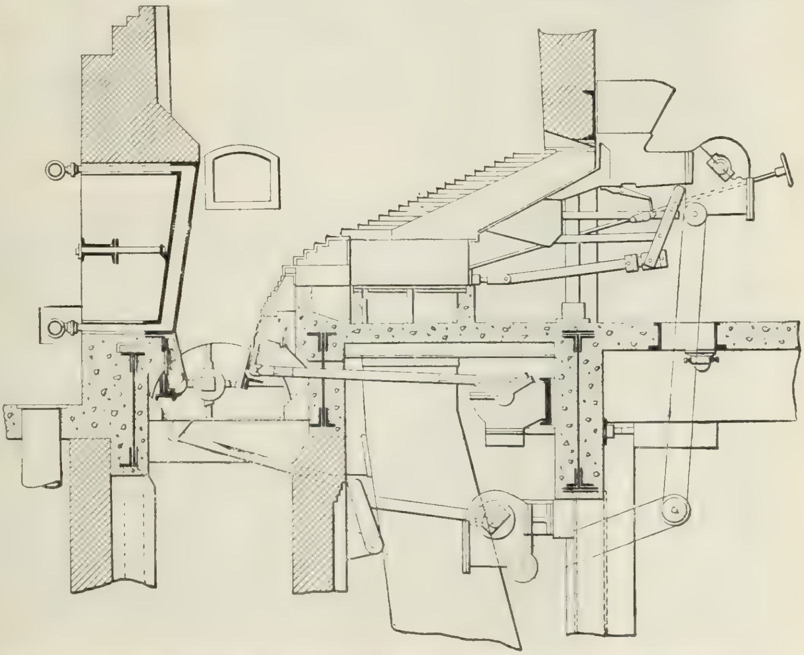


FIG. 7. BEACON LIGHT CO., CHESTER, PENN. WATER-COOLED BRIDGE-WALL, TAYLOR STOKER

found by actual try-out that in the clinker pit moving metal projections in contact with hot clinker were prohibitive, as they rapidly burned away.

About 1910 the suction vacuum system of ash removal was coming into wide use. To successfully handle ashes in this system they must be neither too wet nor too hot. The clinker grinder that used water for cooling the grinding roll had, therefore, to get along without water or with so little of it that the ashes are reasonably dry when discharged.

The designer of the modern grinder strives for the following:

1. To have cool clinker in contact with the grinding roll. To accomplish this he must provide a clinker pit sufficiently deep and of adequate volume to admit of letting the clinker lie in the pit long enough to cool before grinding, and to accomplish these under the combustion rates prevailing in everyday plant operation and with the coals available to the plant.

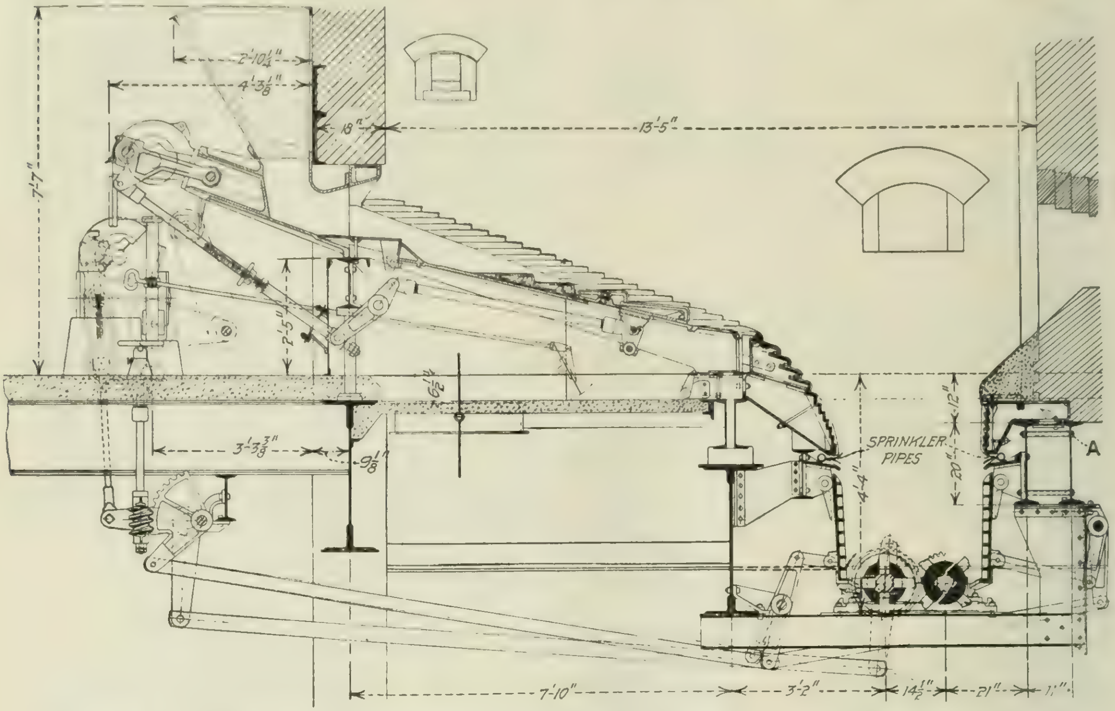


FIG. 8. COMMONWEALTH EDISON CO., CHICAGO. WESTINGHOUSE TYPE CLINKER GRINDER

Note volume of clinker pit, the sprinkler pipes and double rollers, also air admission at *A* under bridge-wall. An unusually interesting grinder.

2. To give wide flexibility of ash-discharge rate through the grinder and provide for dumping at once the entire content of the clinker pit.

3. To get a pit of such depth and shape that when it contains a normal quantity of ash and clinker, the mass in the pit will resist the passage into it of air from the overfeed or other part of the stoker; that is, so resistant to air and gas flow that these will be directed upward into the combustion space and not down into the mass in the pit, where its presence might accelerate combustion of the carbon there and damage the grinding roll and other parts by overheating them. It is seen, therefore, that the clinker should not be allowed to arch up or bridge on the lower part of the stoker and thus form or encourage the formation of an air passage directing air toward the bottom of the clinker pit.

4. To provide a rugged grinding roll.

5. To provide an air-cooled or water-cooled back for the brick wall side of the pit to avoid the sticking and growth of clinker to this wall.

6. To discharge the clinker in small particles, cool and reasonably dry.

The first of the modern clinker grinders was applied to a Taylor type stoker in the plant of the builder of the stoker in 1911. The following year a grinder, Fig. 6, was used under one of the 2365-hp. double Stirling type boilers in the Delray Station of the Detroit Edison Co. This grinder had a shallow clinker pit—a too shallow pit—but this was unavoidable.

The grinders for the boilers in the Connors Creek Station and in the large Park Place heating plant in Detroit, both of comparatively recent construction, have pits much deeper than the one in the Delray Station.

Following are some figures giving the combustible in the ash from the Delray plants. While the grinders in No. 2 power house show an appreciable reduction in combustible in the ash compared with operation there without grinders, the results are not as good as those obtained today.

ASH ANALYSIS DELRAY STATION, 1916

Month	Per Cent. Combustible in Ash		
	Power House No. 1 Dumps	Power House No. 2 Dumps	Power House No. 2 Grinders
March	17.524	17.662	14.024
April	17.632	24.278	17.048
May	14.758	21.402	16.608
June	21.685	21.412	16.650
July	18.640	27.727	15.658
August	22.172	26.424	16.222
September	22.170	34.285	20.702
October	23.345	30.752	18.137
November	21.96	20.982	18.998
December		....	..

In the Park Place Station the crew had in 1916 begun to get the combustible in the ash down to a gratifyingly low percentage as will be seen from the figures following. So many of the engineering staff of the Detroit Edison Co. have been in Government service during the war that recent performances of the clinker grinders in the company's plants are not forthcoming.

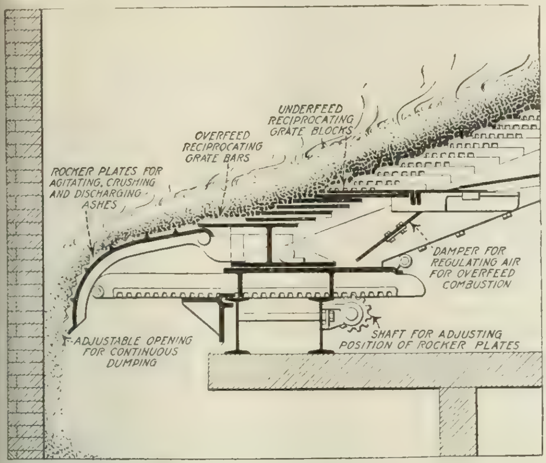

UNDERFEED RECIPROCATING GRATE BLOCKS
OVERFEED RECIPROCATING GRATE BARS
ROCKER PLATES FOR AGITATING, CRUSHING AND DISCHARGING ASHES
DAMPER FOR REGULATING AIR FOR OVERFEED COMBUSTION
ADJUSTABLE OPENING FOR CONTINUOUS DUMPING
SHAFT FOR ADJUSTING POSITION OF ROCKER PLATES

FIG. 9. THE ROCKER PLATES MAY BE RAISED OR LOWERED TO INCREASE OR DECREASE THE DISTANCE BETWEEN THE PLATES AND THE BRIDGE-WALL

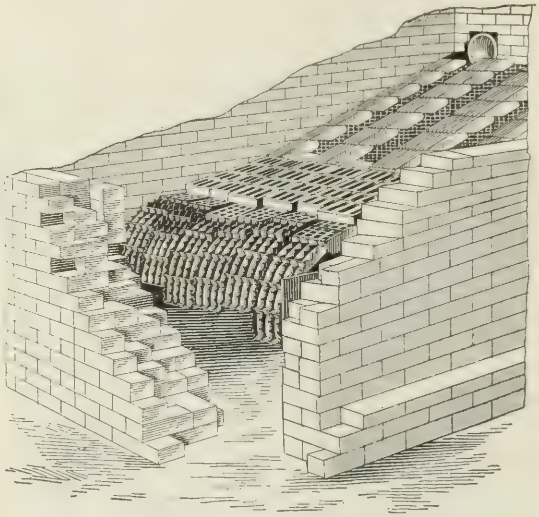


FIG. 10. LOOKING TOWARD THE ROCKER PLATES

About 1913 a grinder which was a development of and an improvement on the old Murphy grinder was attached to a Taylor type stoker in the plant of the Rochester Railway and Light Co. There was practically no clinker pit owing to lack of space to accommodate it.

PERCENTAGE CARBON IN ASH WITH CLINKER GRINDERS, PARK PLACE, 1916

January	11.997	May	11.865	September	8.325
February	12.954	June	9.942	October	6.907
March	13.672	July	16.380	November	8.280
April	13.847	August	38.160	December	9 342

The standard clinker grinder furnished with the Taylor type stoker is shown in Fig. 3. Notice that to the left of the roller is a movable plate, called a crusher plate, which may be moved toward or away from the grinding roller, thus enabling the operators to grind the clinker coarse or fine and discharge it slowly or fast as required. Notice also that the dump plate may be dropped to the wide-open position. To prevent clinker sticking to the extension grate at the foot of the tuyeres, the grate is given a pitch that will drop the clinker by gravity yet give a change in slope that will not be abrupt enough to split the fuel bed.

The air admission to the overfeed grate is controlled from the boiler front, the purpose of the grate being, of course, to consume the combustible before it gets on the grinding roll. Each roller is made up in sections bolted on a square bar. It may be driven from the main stoker drive or separately, with variable speed. The roll revolves slowly and only a part of its surface is exposed directly to the hot clinker. The chief function of the waterback is to prevent clinker "freezing" to the bridge-wall. The waterback in the standard Taylor grinder is not under pressure, and the inlet and outlet openings are accessible for convenient observation and inspection.

Fig. 2 shows an interesting clinker grinder used with a Westinghouse type stoker in one of the latest types of boiler settings in the L Street Station of the Edison Electric Illuminating Co., Boston. The air admission to the lower part of the stoker is controlled, and the air openings in the lower part of the extension grate, just above the crusher plate, are directed downward. The clinker pit, if one may use that term to designate the volume above the grinding bar and up to the extension grate and bridge-wall, is very

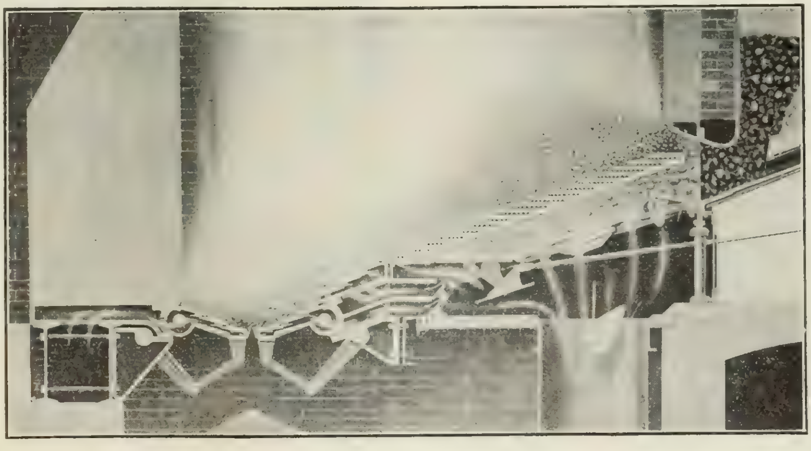


FIG. 11. SHOWING THE DOUBLE DUMP GRATE WITH AIR ADMISSION THROUGH HORIZONTAL OPENINGS IN EACH GRATE

deep, being 3 ft. 10 in. The purpose of such a depth is to insure that the clinker will be cool before it reaches the bar. No waterback is used, but instead a sprinkler pipe located where it will be most difficult for it to become plugged with ashes and dust is used to cause a film of water to flow over the plates, cooling the clinker so that it does not adhere to the plates. Of course the water therefore keeps the grinding bar cool.

The coals usually burned in this station are the low-ash Eastern coals. The grinder has not been in operation long, but the carbon in the ash discharged by it now averages about 7.5 per cent. with New River coal.

Fig. 8 shows a clinker grinder used with a Westinghouse type underfeed stoker in one of the stations of the Commonwealth Edison Co., Chicago. Notice particularly the slope of the overfeed extension-grate part of the stoker. These grates move, of course, and have air passages in them, the purpose being to agitate the clinker, breaking it and exposing to the air for combustion the combustible contained in it.

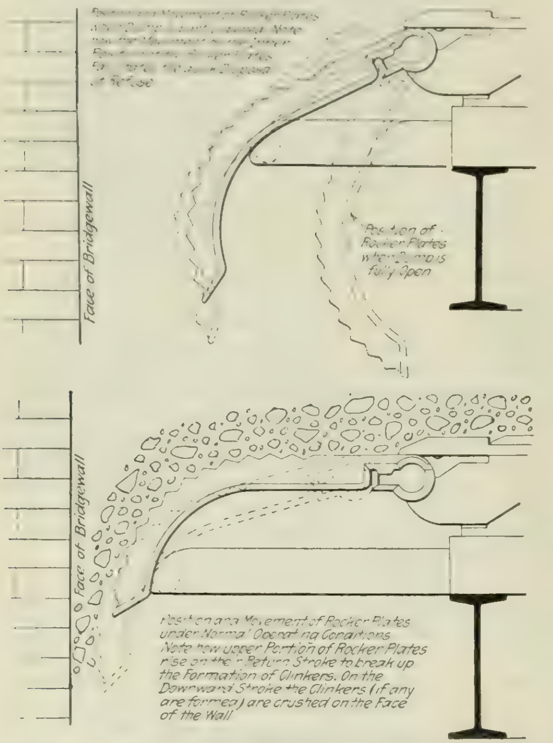

Face of Bridgewall
Position of Rocker Plates when Dump is fully Open
Face of Bridgewall
Position and Movement of Rocker Plates under Normal Operating Conditions
Note how upper Portion of Rocker Plates rise on their Return Stroke to break up the Formation of Clinkers. On the Downward Stroke the Clinkers (if any are formed) are crushed on the Face of the Wall

FIG. 12. SHOWING THE VARIOUS POSITIONS OF THE RILEY ROCKER DUMP PLATE

As far as air supply is concerned, one notices also in this grinder that an auxiliary air duct is provided in the bridge-wall at *A*, and air is discharged into the clinker mass from the bridge-wall side as well as from the overfeed-grate side. Sprinkler pipes and adjustable crusher-plates are provided. Notice that two grinding rolls are used. The clinker pit is one of the deepest yet used, being 4 ft. deep. The experience of the designers of the Taylor-stoker clinker grinder convinces them that air-cooled backs for the bridge-walls are impracticable for most plants, owing to the large cooling surface required. Water-cooled backs are not without disadvantages, but they are the most practicable, in the judgment of these designers. The low-pressure waterback is, of course, more widely used than the high-pressure. Fig. 4 shows an air-cooled back, and Fig. 5 a high-pressure water-cooled back.

The clinker grinder or crusher standard with the Riley type stoker differs from the grinder or rotary ash-discharge machines described herein. The overfeed reciprocating grates do not have a steep slope as they approach the clinker or rocker plate, but have the same inclination as the underfeed grates. The rocker plate with which nearly all engineers are familiar, but which it is necessary to describe here, to be complete, is made up in sections as shown in Fig. 10. Each section has an up-and-down movement in the opposite direction to the motion of its immediate adjacent section; that is, each section end next the bridge-wall moves vertically. The purpose is to agitate and crush the clinker. The distance between the rocker plate and the bridge-wall is adjustable to give continuous dumping of the ash (see Figs. 9 and 12).

While this clinker-crushing and agitating device is simpler than the rotary ash-discharge machines, it functions well, as the following performance figures reveal:

Rated Boiler Horsepower and Station Name	Per Cent Rating	Combined Efficiency Per Cent	B.t.u. Value of Coal	Per Cent. Ash in Coal	Per Cent Combustible in Ash
1373 Essex Station, Public Service Electric Co., Newark, N. J.	102.7	80.2	13,916	10.40	11.84
	110	81.1	14,410	7.36	15.43
	141	81.8	13,836	10.81	11.44
	145.2	81.4	14,086	10.53	16.67
	148.1	80.5	14,206	9.58	14.57
	153.9	78.5	14,234	8.71	10.64
509, Interborough Rapid Transit Co., New York City.....	209	72.2	14,534	7.00	4.9
	233	72.0	14,511	7.11	14.29
	331	68.4	14,001	9.95	21.57
444.................	302	76.4	10,775	15.34	20.26

Considering the simplicity of the device compared with rotary grinders, the rocker plate produces surprisingly good results in the way of burning out combustible in the ash, for it is to be presumed that an amount of combustible reaches the rocker plate comparable to the amounts usual with other underfeed stokers.

The engineers designing the Riley type stoker have been reluctant to adopt the clinker grinder or rotary ash discharge as developed up to date, though their affiliation with the Murphy Iron Works puts them in possession of much valuable experience. Sanford Riley points out to me that experience shows that for the commercially complete burning out of combustible in clinker at the refuse end of any stoker, agitation and breaking up of the clinker at the points of air supply and before the grinding bars are closely approached by the combustible is vitally essential to efficient and successfully continuous operation. Of course this is true generally, and particularly for coals the clinker of which is dense instead of porous.

The coal-mine mechanic must be resourceful. He must keep the mine machinery going whether he has anything to keep it going with or not. If an engine or pump breaks down and no spare or repair parts are to be had, he must repair it anyway and keep it running, says *Coal Age*. Otherwise the mine may be compelled to shut down, either in whole or in part.

Some engineers are of the opinion that any kind of coal can be burned on any kind of furnace grate. It is better to know what kind of grate to use before installing than to learn by failure.

"Karge" Cushion and Flexible Coupling

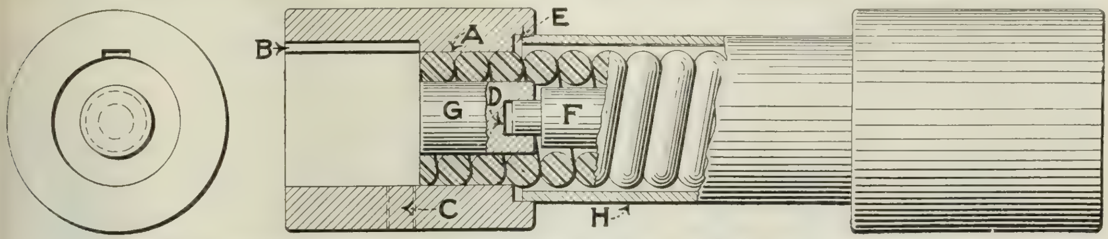


FIG. 1. SHOWING DETAILS OF CONSTRUCTION OF THE "KARGE" FLEXIBLE COUPLING

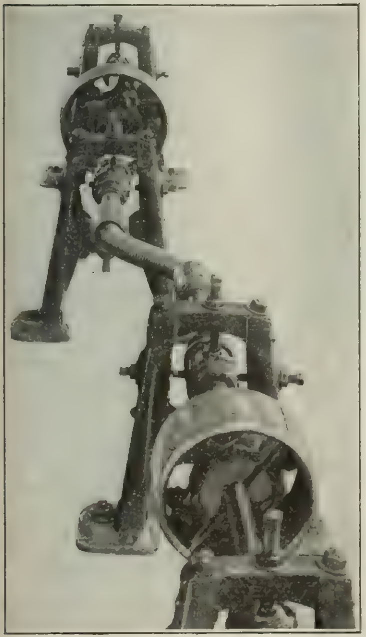


FIG. 2. COUPLING WITH OFFSET

Many designs of flexible couplings have been used for connecting shaftings in order to eliminate mechanical troubles due to misalignment, and although they have served their purpose to good advantage, there is always room for improvement This seems to be borne out by the introduction of the "Karge" cushion and flexible coupling manufactured by the Three Rivers Machine Tool and Die Corporation, Phoenix, N. Y. The coupling is designed to take the place of flexible joints, gears, pulleys, beltings and any other mechanical devices used for the transmission of power. Its claims are that it reduces friction, absorbs shock, protects vital mechanism, needs no lubrication, promotes smooth action among working parts and permits of no slipping between the driven and driving units. The cushion coupling is constructed of a special alloy steel and consists of a coil within a coil, wound in opposite directions. In other words, the coupling proper is formed in a cylindrical shape, so that it resembles a helical spring in appearance, and this coupling member is shrunk in the sleeve at each end. This means being secured to the shaft or machine, as the case may be. A flexible arbor extends through the center of the coil, with a clearance between which allows free elasticity of the coil over the arbor and will prevent the coil from going beyond its elastic limit. At the same time it utilizes the tensile strength of the steel, which is greater than the torsional strength of the shaft. A flexible sleeve is also placed on the outside of the coils for the same purpose as the arbor.

Where the flexible coupling is applied to a shafting or as a connection between two units, it can be bent and placed at almost any angle and will absorb all shock and strain and deliver a load in a satisfactory manner.

Fig. 1 shows the details of construction. The end of the coupling is secured to the shaft by either a key or setscrews, as shown at *B* and *C*. The space between the plug and the floating arbor is to allow for contraction and expansion of the spring lengthwise, as shown at *D*. The space between the coupling and sleeve is to allow for contraction and expansion of the spring lengthwise, as shown at *E*. As already stated, the floating arbor *F* limits the contraction of the spring and has a sliding movement in the plug *G*, which plug makes the end of the spring solid, and the sleeve *H* limits the expansion of the spring and has a solid sliding movement in the coupling.

Figs. 2 and 3 illustrate two applications of the flexible coupling, one showing a decided offset and the other a right-angle turn. All couplings are made of cast iron and the compression sleeves of steel. It is the practice to make the inside diameter of the coil spring the same as the outside diameter of the shafting with which it connects. When constructed in this manner, the couplings are claimed to have 30 per cent. more strength in torsion than the solid steel shaft. The devices are at present made in various sizes for shafting from ½ to 6 in. in diameter.

Government Has Its Own Coal Yard

A Government coal yard, supplying the various Federal departments and buildings, will begin operations in Washington on May 1. The yard is capable of handling 1200 tons daily and has a storage capacity of 30,000 tons. The decision of the Government to handle the coal for its own use was made as a result of the success of the Interior Department in doing so last winter during the coal shortage. Accordingly Congress appropriated over $400,000 for constructing the yard and over a million for maintenance and operation.

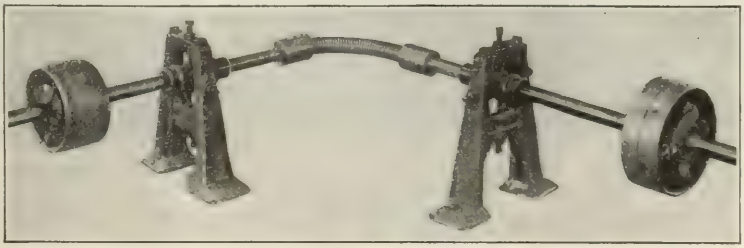
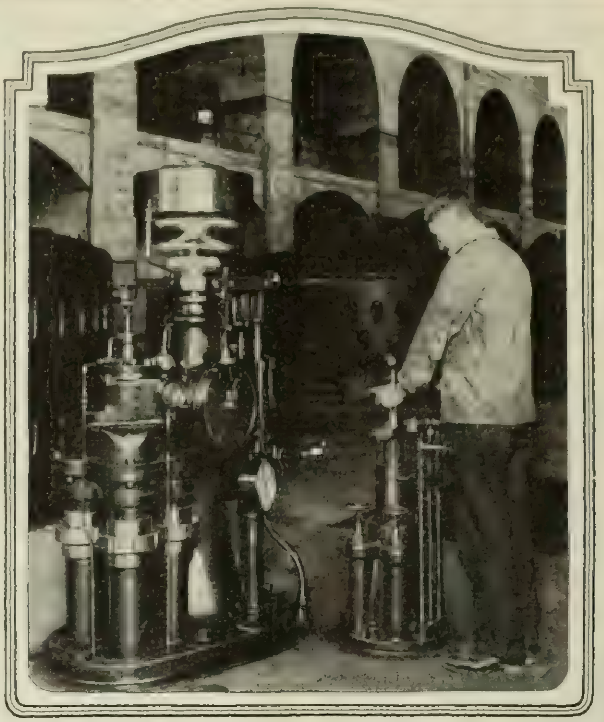


FIG. 3. COUPLING WITH RIGHT-ANGLE TURN

GOVERNORS at HOLTWOOD

By F. H. Rogers*



THE governors at the hydro-electric station of the Pennsylvania Water and Power Co., at Holtwood, Penn., control the speed of five 13,500-hp., two 17,000-hp. and one 16,500-hp. turbines. It is not the intent of this article to describe the mechanical details of these governors, but to cover the subject of regulation in a broad sense by a discussion of the principal requirements of governors for hydraulic turbines and the methods of securing, in the design and construction of the governor, the desired results as exemplified in the Holtwood Station. [The first of the Holtwood articles, telling how the power-house crews are trained, appeared in *Power*, Mar. 25.] The principal mechanical elements that must be used in all governors consist of: (1) A governor head driven from the turbine shaft, containing flyballs controlled by springs, the flyballs being connected to a pilot valve controlling the main governor valve; (2) a first compensation consisting of restoring mechanism connecting the gates of the turbine to the pilot valve; (3) a secondary compensation.

This combination of elements functions in the following manner: When a load change occurs on the generator, the resulting speed change causes the flyballs to move from their central position and this operates through a pilot valve and the main governor valve, causing the turbine gates to move. As the gates operate, the pilot valve is moved back toward its central position by the restoring mechanism, but owing to the unbalance between load demand and power supply, the speed continues to change and the gates to move. When the position of balance between demand and supply is reached, the speed ceases to change so that a slight additional movement of the gates restores the pilot valve to its central position and stops the gates. At this point in the operation, the speed of the generator is either too high or too low, depending on whether the change in load is a reduction or an addition, and the speed must therefore be brought back to normal. This is accomplished by the secondary compensation acting through the pilot valve. The requirements for a governor for hydraulic turbines may be divided into the following headings: (1) Regulation, (2) Steadiness or stability, (3) Reliability, (4) Simplicity, (5) Durability. That a governor may properly regulate the speed of the unit, it should be sensitive; that is, respond quickly to sudden changes of speed and also to slight changes of speed. The quality of steadiness, or stability, is an important one and involves freedom from unnecessary gate movements or movements occasioned by conditions other than changes of load on the unit. Thus, not only is it necessary for a governor to respond to changes of load, but it is equally important that it shall not act when there is no change of load.

The reliability of the governor is of as great importance as the reliability of the turbine itself, since the operation of the turbine depends on the governor that controls it. Therefore, an unreliable governor is a continuous source of risk in the operation of the turbine unit altogether aside from the question of the speed regulation obtained.

Owing to the unusual requirements in connection with the governing of hydraulic turbines, the governor must of necessity be a complicated mechanism. So it is of importance to simplify the design and method of operation of the governor as far as possible without detriment to the performance required of it. In most hydro-electric stations the cost of main-

Holtwood is on the Susquehanna River about fifteen miles from Lancaster, Penn., and forty from Baltimore. At present the hydro-electric station, owned by the Pennsylvania Water and Power Co., has a capacity of 118,500 hp. in eight units generating 83,500 kw.; the head is 63 ft. Current at 70,000 volts is transmitted to Baltimore and Lancaster.

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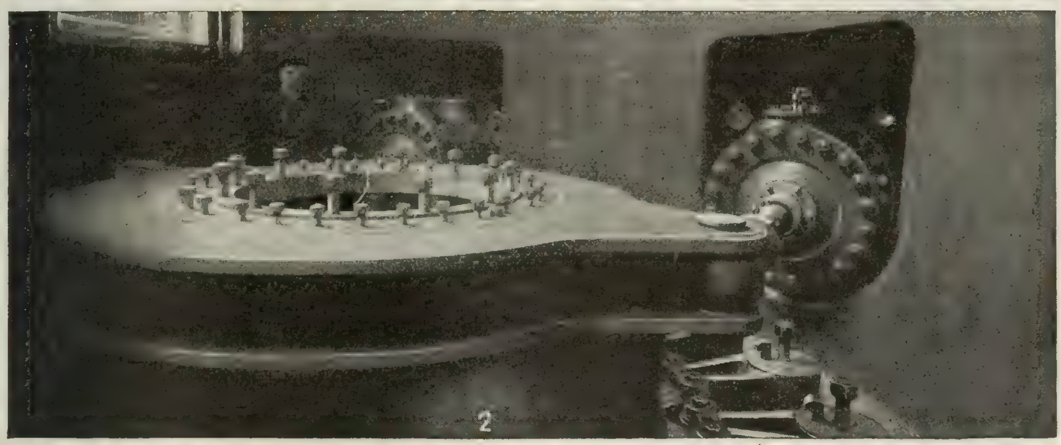
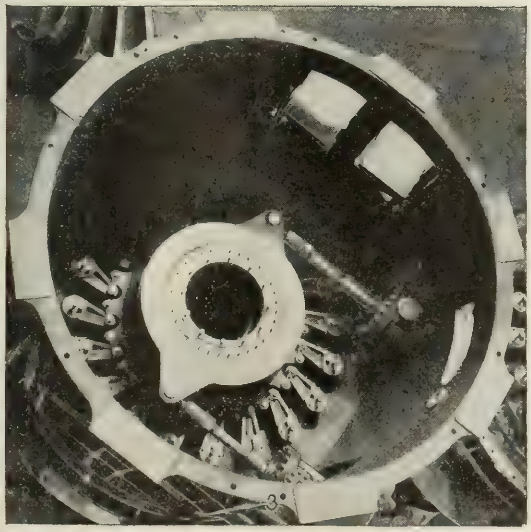
*Hydraulic Engineer, William Cramp & Sons Ship and Engine Building Co., Philadelphia.





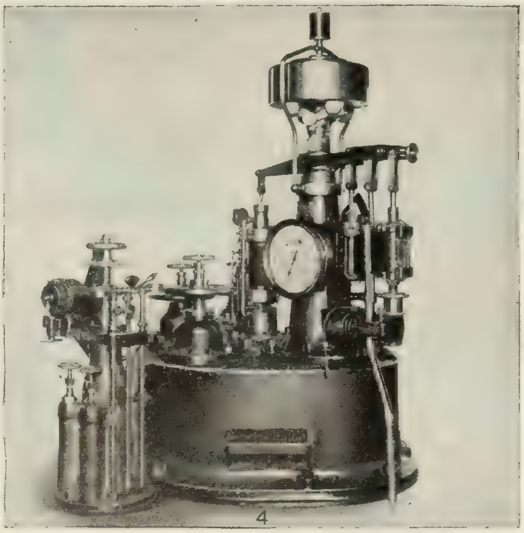


FIG. 1. INTERIOR OF GENERATOR ROOM, HOLTWOOD. FIG. 2. LOOKING TOWARD THE OPERATING CYLINDERS. FIG. 3. TYPE OF TURBINE IN WHICH OPERATING MECHANISM IS SUBMERGED. FIG. 4. THE I. P. MORRIS DOUBLE FLOATING LEVER GOVERNOR

tenance of the governor is higher than the maintenance of all the rest of the turbine and it is therefore economical to install the most serviceable governor that can be obtained, irrespective of first cost, to insure continuous operation of the unit without the necessity of shutting down for repairs or adjustments to the governor.

The governor is made extremely heavy and rigid, so that the design is in keeping with the heavy construction characteristic of the large hydraulic turbines. The governor head is extremely powerful; that is, the flyballs are heavy so that a comparatively small change in speed produces a great centrifugal force to actuate the pilot valve. That as much of this power as possible may be available to move the pilot valve the friction in the connections between the flyballs and pilot valve is reduced by the use of ball bearings at all joints, securing the sensitiveness required of a governor which must respond quickly to sudden changes of speed and one which will move the gates for every slight change in speed.

The use of a heavy governor head also results in steadiness in operation, so that the governor does not function when there is no change of load. It is often noted in hydraulic plants that the gates of the turbines are constantly swinging back and forth when no load change is taking place. This is spoken of as hunting of the governor and may be due to a number of causes, such as variation in the governor pressure, defective drive or mechanical friction in the valve or valve connections. Where a light commercial governor is used, this constant swinging of the gates is noticeable and soon starts wear in the operating mechanism of the turbine. Such wear results in a cumulative increase in the movements which caused it, so that the hunting increases. These defects are greatly reduced by the elimination as far as possible of friction in the connections and the use of a powerful governor head, as the heavy flyballs will resist any outside influences tending to move them from their central position, and will function only when there is an actual change in speed of the machine.

To prevent hunting and insure steadiness of operation, it is of vital importance to eliminate all lost motion in the restoring mechanism In the I. P. Morris double floating lever governor all gears, screw threads, or racks, are omitted in the restoring mechanism, making all connections between the parts constituting the restoring mechanism by means of hardened steel pins and bushings, ground to a fit.

A governor should have as few and as simple adjustments as possible for the functions which it has to perform and must be so designed that these adjustments can be made while it is in operation. Among these adjustments might be mentioned:

1. Change of Normal Speed of Unit—This adjustment is required for synchronizing the unit. The governor is fitted with a handwheel and motor for this purpose, so that the speed of the turbine may be altered either at the governor or through the motor from a distant point such as the switchboard.

2. Inherent Speed Change—This adjustment is required so as to give a change in normal speed from full-load to no-load conditions, so that the generators may be properly operated in parallel and equally divide the load. This governor is furnished with a small handwheel connection so that the inherent speed change from no load to full load may be altered anywhere between limits of zero to 3 per cent. This adjustment may be made while the governor is in operation.

3. Time of Gate Movement—This adjustment is required so that the turbine gates may be moved in a time period to suit the length of the water passages and the velocities used in any particular plant. This governor has an adjustment for changing the time of gate movement which can be made during the operation of the governor, although it is usual in a given plant when the governor is first installed to fix this time of gate movement to suit the local conditions.

[*The article which will follow this one deals with Normal and Abnormal Operation of the Governor System, of which the governor itself is only a part. Next will come one treating of how the governor system is maintained at Holtwood, followed by others dealing with details of operation and maintenance of particular parts of the system.*—Editor.]

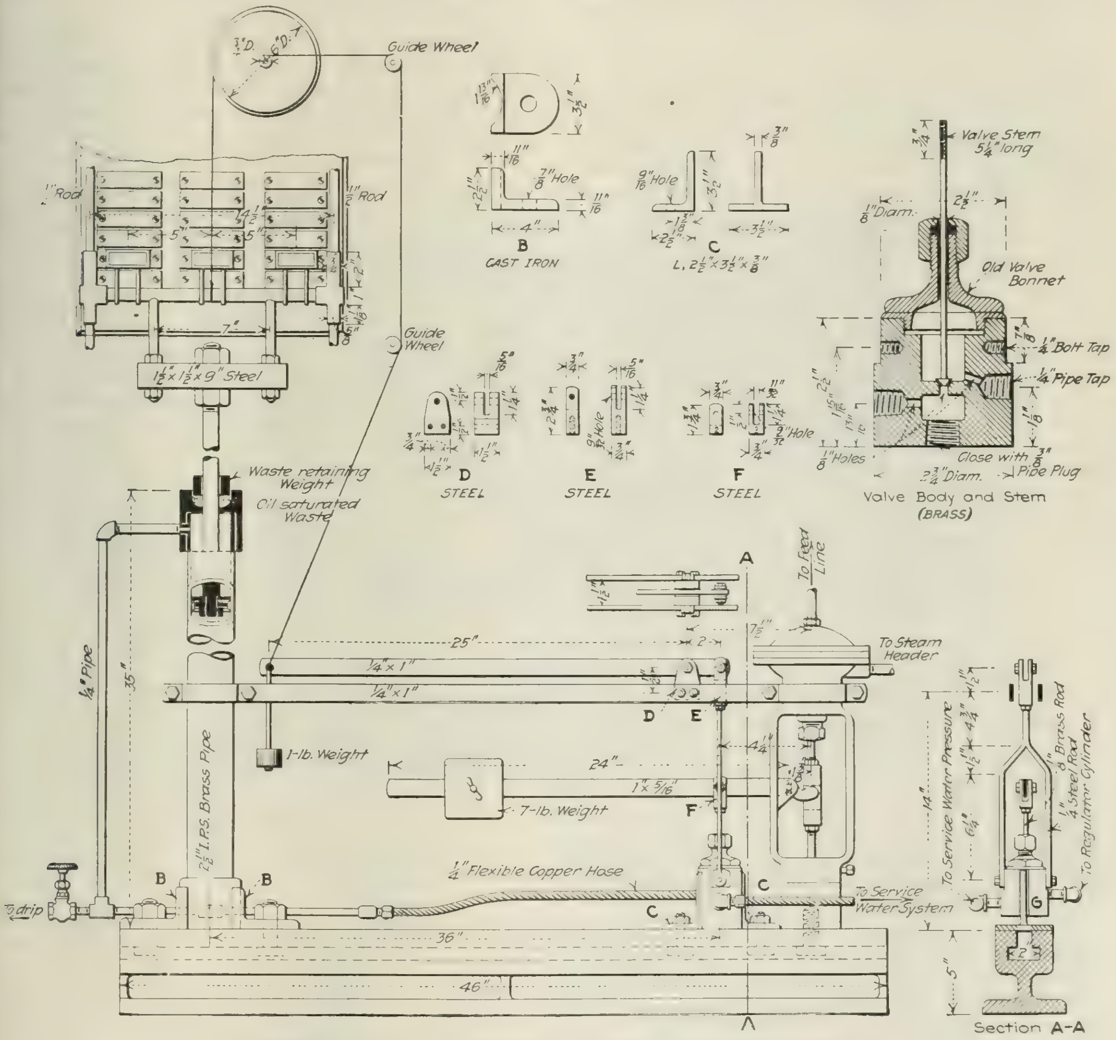
Constant Excess-Pressure Regulator for Motor-Driven Pumps

By C. H. SONNTAG

THE maintenance of a constant excess pressure in boiler-feed lines over the pressure in the boiler is of decided advantage. When hand regulation of the individual feeds is used, it means that a given opening of the feed valve will always feed water at the same rate. If automatic feed regulators are installed on the boilers, this point is not quite so important, but in any event the building up of high pressure when the feed valves all happen to close at once is prevented, and the operation of the pump is controlled without the necessity for personal attention.

Control of steam pumps on this principle has been worked out by several makers who furnish regulators for the purpose, but so far as the writer knows, the control of motor-driven pumps along the same lines has not come into general use. In our plant the boiler-feed pumps are fitted with constant excess-pressure governors, but we had more exhaust steam than we needed to heat our feed water, so we installed a motor-driven triplex-feed pump, which gave us the benefit of the superior steam economy of our main generator.

The accompanying drawings show the regulator that we designed for the control of this pump. It works on the familiar follow-up motion principle, such as is used on steam steering engines and similar devices. The base casting was made from an old motor rail. The diaphragm chamber and parts below it are from a 1½-in. constant excess-pressure steam-pump governor. The motor used is of the wound-roter type, and the three brush-holders of the regulators, being in metallic contact with their supporting arm, short-circuit more or less of the resistance in the rotor circuit, according to their position on the face of the contact panel. The subdivisions of the rotor resistance are equal in the three phases, but the dimensions on the panel drawing show that corresponding sections of this resistance in the three phases are shunted successively instead of at the same time. This gives three times as many subdivisions of speed as there are contacts on the panel, and the result is very smooth acceleration, with a speed for almost any rate of feed. Of course it slightly unbalances the rotor currents, but with so many divisions there has been no untoward behavior of the motor.



SHOWING DETAILS OF THE MOTOR-DRIVEN PUMP REGULATOR

This regulator does not open the primary circuit of the motor, nor stop it, but if the resistance is properly chosen, it will bring the motor down to a very low speed. The pump is fitted with a spring-loaded relief valve set above the working pressure, as a safety device in case of absolute stoppage in the discharge line. The panel is so connected to the resistance that the lowest position of the brushes shunts all the resistance.

To start the pump and regulator in service, see that the valves leading to the upper and lower diaphragm surfaces are open, also the one supplying service-water pressure to the follow-up. The drip valve should be open enough to let the plunger and brush rigging down slowly when the follow-up valve is closed. Then hold the follow-up valve open by raising the upper lever until the brushes are at the top of the panel and close the primary switch, when the motor will start slowly. Release the follow-up valve and the motor will accelerate until the desired excess pressure is reached. This excess pressure is determined by the position of the 7-lb. weight shown on the lever arm in the illustration. Fifteen pounds is about right for boiler feeding.

The application of the follow-up principle to this purpose, and most of the details of the regulator were worked out by our chief engineer, C. A. Crass. He later became first assistant engineer of the Emergency Fleet Corporation Steamer "Lake Edon," and was killed when that vessel was torpedoed in European waters on Aug. 21, 1918.

Protecting Polyphase Induction Motors from Single-Phase Operation

By B. W. JONES

Engineer, Industrial Control Department, General Electric Company

Comparison is made of the different means generally employed to prevent a polyphase induction motor from operating single-phase and also from overheating.

TWO-PHASE and three-phase induction motors are used for a great number of applications where polyphase alternating current is available. The current per phase of a three-phase motor is more than the current per phase of a four-wire two-phase motor having the same horsepower and voltage rating. To illustrate, the full-load current per phase of a 40-hp. three-phase 220-volt induction motor is approximately 100 amperes, and the full-load current per phase of a two-phase motor of the same rating is approximately 87 amperes.

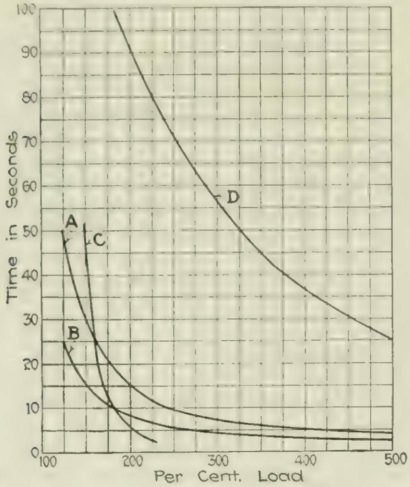


FIG. 1. CHARACTERISTIC CURVES OF MOTOR PROTECTING DEVICES

If one line or phase to either of these two types of motors breaks, or a fuse blows, or for any reason open-circuits, the motor will continue to run on single-phase power, provided the torque does not exceed the single-phase torque, but with an increased current in the remaining single-phase circuit. This current will be approximately 175 amperes for either motor of 40-hp. capacity when driving full load. Since the heating of the motor varies approximately as the square of the current, the three-phase motor will have to dissipate about three times and the two-phase motor about four times the heat per phase that they would have if they continued under multiphase or normal condition. This explains why polyphase induction motors burn out if they are operated single-phase when driving approximately full load.

There are several methods employed to disconnect the motor from the line when one of the phases fails. The most common means used is two inverse time-limit overload relays per motor, which control a line contactor. To get the best protection from this type of relay, it should be calibrated with the dashpot removed on a current about 10 per cent. higher than that required to drive the load. This adjustment should then never be changed. With the dashpot and oil replaced, the oil vents should be adjusted so that the relay will not function during starting; that is, the plunger should not be allowed to rise so high that it will not return after the motor has fully accelerated. If later, the relay does completely function during starting, owing to its parts wearing or for any other cause, the oil vents should be decreased, but the current adjustments should never be changed.

With this means of protection a motor is protected against ordinary overloads above 10 per cent. and also against overloads in any of the phases caused by a single-phase action. If the motor is running light or has only a partial load on single-phase power, such that it would not require 110 per cent. current, the motor will not overheat and the relays will not function, which is a satisfactory condition. Of course the relays should be in both the starting and the running circuit, unless the equipment is hand-operated and the operator can be relied upon to take the needed precautions, so that if the motor did not start with the single-phase power, the relays would permanently disconnect it.

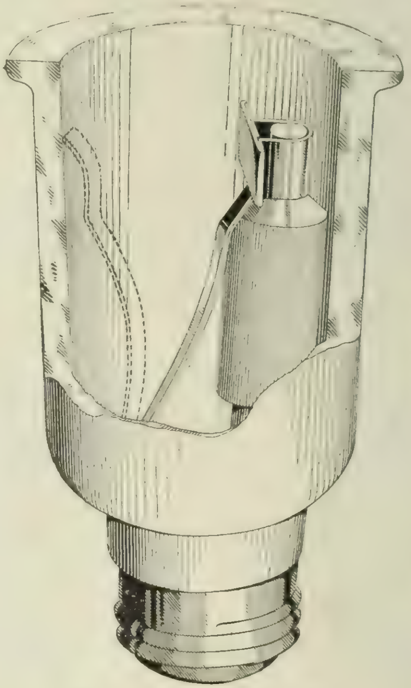


FIG. 2. PROTECTIVE PLUG

Fig. 1 shows two typical curves of an inverse time-limit overload relay which was set to trip on 110 per cent. full-load current, as already described, and set with two different adjustments of the oil vents. Curve *A* shows the time-current conditions with a small vent, and curve *B* with a larger oil-vent adjustment.

Suppose the two 40-hp. induction motors were equipped with two of this type of relay per motor, those for the three-phase motor being calibrated to trip on 110 amperes and those for the two-phase motor on 96 amperes (110 per cent. of full-load current) and the dashpot on each was adjusted as shown in Fig. 1, curve *A*. If these two motors were running and each driving a full load and one of the phases on each motor should open circuit, each would require approximately 175 amperes, as previously explained, to keep them running. Since 175 amperes represents 175 per cent. of full load or rated current for the three-phase motor and 200 per cent. for the two-phase motor, the three-phase motor will be disconnected from the line, as per Fig. 1, curve *A*, in 20 sec., and the two-phase motor in 15 sec., as indicated by the dotted lines. If the dashpots were adjusted as shown in curve *B*, the three-phase motor would be disconnected in 11 sec. and the two-phase motor in 8 sec. If the dashpots were calibrated with a smaller oil vent than as represented in curve *A*, the time required to disconnect the motors would be proportionately longer. Therefore, since these motors will not become damaged in this time with 175 amperes per phase, the relays will give adequate protection.

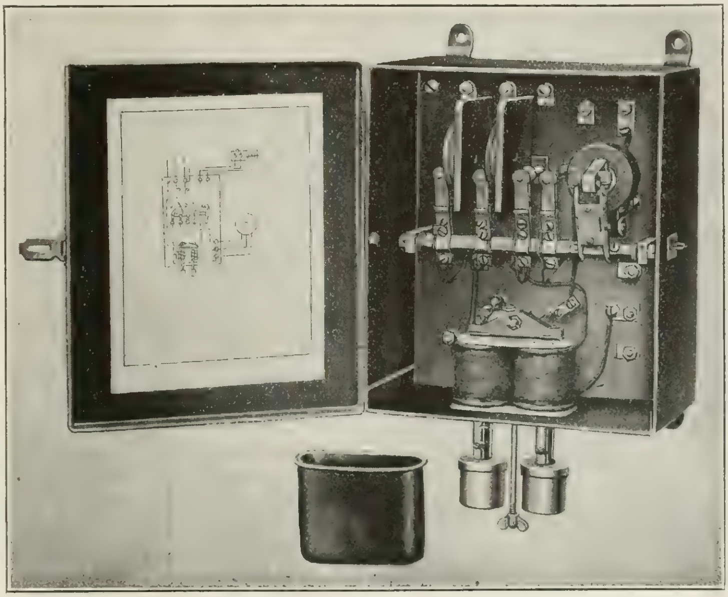


FIG. 3. CONTROLLER EQUIPPED WITH TWO INVERSE TIME-LIMIT RELAYS

A number of instances have happened where motors that have had this type of relay for protection have burned out. In every case the cause could be traced to one of two reasons and sometimes both. When the relay leaves the factory, it has the current adjustment correctly set for a specified motor. When the relays are actually applied, they may or may not be for a motor of the same rating and also the adjustment may have been changed. In other words, the current adjustment is not correct; namely, 110 per cent. of the motor's current rating.

The second reason is that the application is wrong. If a squirrel-cage induction motor is connected to a heavy-inertia load such that it takes five or six times rated current for 10 or 15 sec. or longer to accelerate it, the dashpot on the relay cannot prevent the plunger from pulling up and opening the relay contacts unless the oil vents are completely closed, and this will prevent a reasonable overload from opening the relay contacts in the required time.. For a case of this kind special means must be employed which will give the same protection to the motor as described in the foregoing. However, if the current adjustment is correctly set and the dashpot is capable of giving the required time retardation during the starting period without completely closing the oil vents, a motor need never burn out from overloads or from a single-phase condition when protected with two inverse time-limit relays.

The second means employed for protecting the motor is a standard fuse in each of the phases. A fuse also has an inverse time characteristic, as shown in Fig. 1, curve *C*, but this is fixed and cannot be adjusted to suit conditions. Curve *C* is for an average size of fuse, a large size taking a longer time to open and a small size a shorter time. This type of fuse will blow with 110 per cent. of its current rating after several minutes. If a 100-ampere fuse were applied on the three-phase and an 87-ampere fuse on the two-phase motor specified in the foregoing, the three-phase motor would blow its fuses, under the previously described condition, in 12 sec. and the two-phase motor in 5 sec. as shown in curve *C*, Fig. 1. This curve shows that the motor would have to start very quickly to prevent the fuses blowing during the starting period. The third means employed for protecting the motor is a protective plug, Fig. 2, which has a much longer time characteristic than a fuse. Curves *C* and *D*, Fig. 1, show this difference in time. If applied as stated, the three-phase motor plugs would open in 110 sec. and the two-phase motor plugs in 93 sec. This current-time characteristic approaches the thermal or heating characteristics of the motor and for that reason a plug can be used having the same current rating as the motor. This will allow the motor to start an average load without opening the plug and will also protect the motor against an overload from either a phase failure or an ordinary overload on the motor.

The fourth means employed for protecting the motor is a phase-failure relay which controls a line contactor. This relay allows the line contactor to be closed and opened when the power supply is normal, but if any phase fails with the motor running, the relay will instantaneously open the contactor and remain thus until reset by hand. This relay has the advantage that no adjustment is required to meet a starting condition and therefore it will always protect the motor against single-phase operation, but it also has the disadvantage that it will not protect the motor from ordinary overloads. This condition must be taken care of by one of the means described, which should also take care of a harmful single-phase condition.

A simple and compact automatic starter combining a line contactor *C* and two inverse time-limit overload relays *R* for throwing small squirrel-cage induction motors on the line is shown in Fig. 3. The line contactor is governed by means of a "start and stop" push-button station in series with the overload relays.

These relays, if calibrated as explained in the foregoing, will give all the protection needed to a motor unless it is driving a heavy inertia load which it must also start.

Economical Operation Must Be Made Certain

By H. S. Rich

The author demonstrates that operating methods should be carefully scrutinized or economies of construction and new business campaigns will go for naught.

THE big items and the important business propositions in many plants seem to be all that the manager and superintendent have time to consider; that is, how more business can be handled, how more raw material can be purchased and stored, how enough help can be procured, how profits can be increased, and how the plant can be enlarged. In short the attention and study of executives seem to be in many instances entirely given to the opening up of new and wider avenues of increased business, whereas the investigation and curtailment of losses and leakages get little attention.

With increased business on one hand there are often increased losses on the other hand, a situation which does not spell economy of operation. For instance, in one large plant more than $250,000 was spent in one summer for new buildings, motors, machinery and various other equipment which necessitated new switchboards and cables being installed in the plant's power house. Of course, all this expense was recalled to mind many times at the foremen's meetings, with the request that labor should be hired as cheaply as possible, more work be turned out with less help, and less waste of time tolerated to counterbalance the heavy expenditures of the plant extensions.

This was good advice when looked at from the official position, but the trouble was not at that end of the business. The great weakness was very evidently along the line of losses, wastefulness and leakages.

REAL OPPORTUNITIES FOR ECONOMY

In this plant was operated a large woodworking shop, and the sawdust, plank ends and blocks were sold to anybody and everybody for 25 cents per 100 lb. (45 kg.). The receipts were often commented upon as being a good rebate on the original costs. Then when any employee wished to purchase leather for shoes, glass for a window or a casting these supplies were sold at cost price, whereas the cost of the clerk's time, the ink and paper and the cashier's time in making out receipts were not charged for. Thus these transactions amounted, in a year, to a larger deficit.

The new manager and superintendent increased the profits of the plant by eliminating these losses in a short time. The sawdust and blocks were not sold but were burned in the boiler house. The firemen complained about mixing coal with so much wood and sawdust, but they were told that it had to be done. It was done, and the coal pile was saved about 25 per cent. daily and thus the season's supply was extended. The firemen's pay was increased 10 per cent. as 2½ lb. of sawdust and wood was required to equal 1 lb. of coal. The sale of supplies to employees was stopped entirely, thus saving a considerable overhead expense.

The next matter of waste was the city water. The last bills were studied, and it was concluded that too much good clean water was being used for sprinkling, washing and uses other than drinking. A piping system was immediately installed by the company's steamfitters through the entire plant and supplied by a fair-sized pump in the fire pump house by the river, whence water was forced to all toilets, forge tubs, foundry hoses and wash basins.

This resulted in the purchase of only 25 per cent. of the original water supply for drinking fountains having small inverted spring faucets of limited flow. Thus the city bill was curtailed, and the over-all saving was apparent at the end of the year even though the cost of piping, supplies and help cost was high. All pipe ends were used up, straps were made and none purchased, and small-sized piping was used wherever possible. Even the river water was not supplied anywhere in wasteful amounts. The forge-shop cooling tanks were not running over all the time but filled when needed, and the hydraulic lifts and elevators were restricted to necessary usage only. The force pump was thus slowed down and kept so through the entire year, with much saving of steam.

ONE GENERATOR DOES THE WORK OF TWO

The used electrical energy offered another large opportunity for saving by lowering the peak and average demand. In the first place, all carbon lamps were replaced with tungsten, thus saving where possible the difference between 3.5 watts per candlepower and 1.25 watts, the specific consumption of carbon and tungsten lamps respectively. For the general lighting of small areas high-candlepower tungsten lamps were used, and for larger areas, such as foundry floors, forge shops and showrooms, the large sizes of nitrogen lamps were found to be the most economical.

All general and bench lighting was supplied with switches in locked steel boxes, and each foreman was responsible for excessive use of electricity. All drop lights were equipped with locked guards to prevent the removal of the valuable lamps. No lights except those actually in use were allowed to burn during the noontime, and during other hours if a machine was idle its light had to be shut off as well as the power, oil and air supply.

The reduction in the use of electricity was very evident on the switchboard ammeters, and during the summer a 100-hp. engine with its generator was usually shut down about 9 in the forenoon, whereas formerly it had been run until noon to supply the load. Thus steam, oil and wear and tear on the two machines were saved, and the life of many lamps was substantially extended.

STOPPING THE SMALL LEAKS

The supply of cotton waste was cut down from 10 lb. (4.5 kg.) per department to 5 lb. (2.25 kg.), and even to 2 lb. (0.9 kg.) for certain fairly clean work, as it was found that much waste was thrown into rubbish when only slightly soiled. The shop porter or janitor had orders to destroy only the worst of the waste, and to return to the foreman any that was but slightly soiled. This caused some grumbling, but when it was found difficult to get new waste the old proved very acceptable.

MOTORS SHOULD NOT RUN IDLE

The electric power was reduced by shutting off all motors not likely to be needed for at least fifteen minutes. Electric elevators were not operated for foot passengers except with loads. One large forge shop had a new four-wire power line run from its power house to a 50-hp. motor, as the old line had caused such a drop in voltage, due to its small size, that five men were needed every morning and noon to help start the large power pulley with a long hooked pole, a task which often took ten minutes or more.

A big item of electrical power is the proper arrangement of alternating-current motors; that is, using a large one only where actually needed, but using small sizes where they are large enough, thus avoiding the use of a large motor to do light work, which lowers the power factor and requires excessive generator capacity.

The matter of wasting steam heat was taken up very seriously in one large factory, and it was satisfactorily settled by having the foremen maintain a comfortable temperature in the departments, using as little steam as possible and not keeping the radiators wide open all day long, thus compelling employees to open the windows to avoid the excessively warm air. One thermometer placed at each end of a large room helps to maintain an even temperature. Where employees are more or less inactive a higher temperature is required than when they are laboriously employed, in which case they demand more fresh air and less heat.

Negligence of Co-Employee

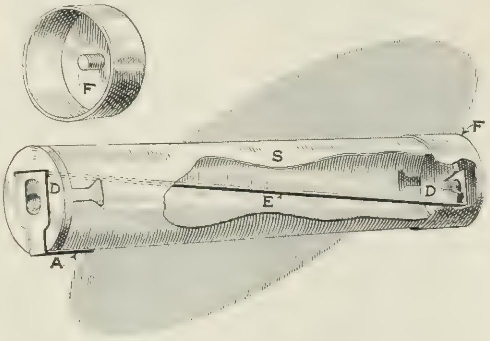
It is the law in Georgia, as in several other states, that an employer is not liable for injury to an employee resulting from negligence of a fellow servant engaged in the same general line of work. This rule has been applied by the Court of Appeals in that state to a case where the plaintiff, a fireman in a steam-power plant, was injured while repairing inside of a boiler. (Parham vs. Berryton Mills, 98 Southeastern Reporter, 241.)

The plaintiff was directed by his superior to make the repairs. While he was so engaged, another fireman, under orders from the same superior, fired an adjacent boiler that was connected with the one in which the plaintiff was working and permitted steam to escape into the latter boiler.

"What was the proximate cause of the injury received by Parham?" asks the court. "It cannot be said that the order from the vice principal and the entering of the boiler at the time by Parham was negligence, for at that time there was no steam in the boiler and there was nothing dangerous about the task. Was not the proximate cause of the injury the act of Alexander (the other fireman), the fellow servant, in opening the valve on the boiler which had steam in it, or the leaving open of the valve on the boiler in which Parham was working? If either be true, and this is the negligence relied upon, it seems to us that the case is controlled by the rule laid down in Civil Code 1910, Sec. 3129, that 'Except in cases of railroad companies the latter is not liable to one servant for injuries arising from the negligence or misconduct of other servants about the same business.'"

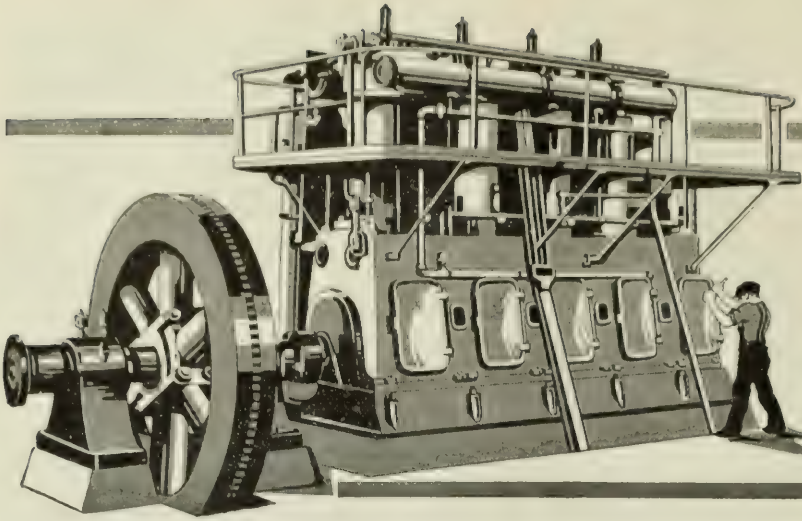
Another Type of Refillable Fuse

A few years ago refillable fuses were a novelty; now they are almost as common as the nonrefillable type. The illustration shows a type of cartridge refillable fuse known as the Volk, recently placed on the market by the Volk Distributors, New York City. This fuse is made up of a fiber shell *S* closed at each end, by metal disks *D* held by two dovetails that pass through the fiber shell as shown. The fuse element *E* is made up in strips of standard form and passed through slots in the metal disks at each end of the shell. After placing the fuse element through the shell, the ends are bent over and the ferrules *F* screwed on, making a firm contact between the ferrules and the fuse element. This fuse has only two removable parts—the ferrules. Up to 60-ampere capacity the ferrules have a machine screw brazed in their center, which threads into the metal disks *D* on the end of the shell. In sizes above 60 ampere capacity knife terminals are used. In this size the ferrules are held in place by two screws threaded into the metal disks *D*. One end of the fuse metal is made long enough to extend beyond the ferrule, as indicated at *A*. On this end is marked the capacity of the fuse element, so that the inspector may see at a glance how the circuit is fused.



SECTIONAL VIEW OF REFILLABLE FUSE

An aluminum alloy containing 10 per cent. of calcium is reported to possess valuable properties. It is lighter than aluminum, easily melted, and machines satisfactorily. It surpasses alloys of copper, tin or zinc with aluminum in its resistance to corrosion, is not brittle, and when cast it conforms to all the details of the mold.



Talks on DIESEL Engines

by L.H. Morrison

XIV—The supplying of high-pressure air for the injection of the fuel charges furnishes a subject of the evening's talk, and air-bottle explosions are touched upon.

"WE'LL look into the subject of air compression and injection this evening," Egan announced when the class had assembled. "We could spend a lot of time if we took up air-compressor construction; but we are interested particularly in operation and the troubles that arise.

"There are three ways of driving a compressor—by direct connection, by belt from the engine, and by a separate motor. It is a very common practice to mount the air compressor on the engine frame and drive it by means of a drag crank on the engine shaft. Such a compact drive is advantageous in motor ships or submarines and in other places where lack of floor space prevents the use of a separate compressor. However, an engine room is seldom so confined. In my opinion it's not a good idea to make the entire engine unit so compact. If anything goes wrong with the compressor, the engine must be stopped until repairs are made. Take the case of our plant here. If all the engines were equipped with direct-connected compressors, on peak loads we would frequently be up against it, for it's always at such times that a compressor valve breaks. As it is, we can disconnect the compressor connecting-rod in a few minutes and cut in the air line from the motor-driven compressor. If all were separate, no delay would occur; merely changing from one compressor to another would keep the engines going.

"On the vertical engine there isn't a great deal of room to work in around the compressor. So I often fear it's neglected. With the horizontal engine the direct-connected compressor is fairly accessible. Where no high-pressure air bottles are used, the short distance from compressor to needle valve allows the engine to begin to fire quicker than with a belted compressor."

"I don't quite get that, chief," Kelly broke in. "I thought all engines had to have air bottles or tanks."

"That is a perfectly natural supposition on your part, Kelly, since all our engines use bottles. However, quite a number of engines use no bottles. They are generally of small horsepower per cylinder, and the scheme is to let the air go direct from the compressor to the injection valve, with no air reservoir in the line.

"This type uses a relief cam that relieves the compression so that low-pressure air may be used in starting. The engine is turned over several times by the low-pressure air. By this time the air compressor has built up the pressure in the air-injection line to around 600 lb. The injection-valve cam is then thrown into action, and the engine fires.

"With most vertical engines no compression relief is used. It requires high-pressure air to turn the engine over against the compression and the friction load, and it would be impossible to use low-pressure air to do this. So it's necessary to have bottles, at least for starting."

"Why not cut them out when running?" Woods inquired.

"A simple answer might be that since the bottles were there, they might as well be open on the line when running," rejoined Egan; "but that is hardly a legitimate reason. Consider an engine in operation, with the compressor delivering all the air required at a particular load, and the suction control valve set so that no excess air is drawn into the compressor to be later blown from the relief valve. Now suppose that a heavy load comes on. The air discharged by the compressor into the air line is the same as before. The heavy fuel charge which the fuel pump has just deposited in the atomizer calls for a higher air pressure to thoroughly atomize it. Most atomizers are designed on the theory that the air pressure will build up behind the heavy fuel charge, and thus proper atomization is secured; but

In the next article, the lubrication of crankshaft bearings, crankpins, piston pins, pistons and helical gears will form the subject for the evening's discussion.

this building up cannot take place when there is no reservoir of air to build up the pressure. Without bottles, there is but a small amount of air between compressor and nozzle and the compressor has completed its stroke before the nozzle opens. Consequently, there is no storage to draw on. Of course the operator can regulate the compressor suction and thus secure a higher pressure, but this can only care for the load changes that are of some permanence. From my viewpoint the air bottle is desirable."

"Well, chief, if some engines don't use air bottles, where do they get the air to start with?"

"It isn't necessary to use high pressure to start with, Kelly, if the engine has a compression relief arrangement. So the starting air in these engines is about 250 lb. pressure. This air is taken from the compressor when the engine is running and stored in the low-pressure starting tanks. The air compressor is always large enough to supply the atomizer and to charge the tanks."

"What about air-bottle explosions?" Woods asked. "The other day a belting salesman was telling us of an explosion he witnessed a year or so ago."

"I guess that was Jones," said Egan. "The explosion occurred at the Fremont plant. I happened to be there and saw Jones do a hundred yards in less than ten seconds. Three bottles gave way, and one of them shot across two blocks. It was pure luck that no one was hurt."

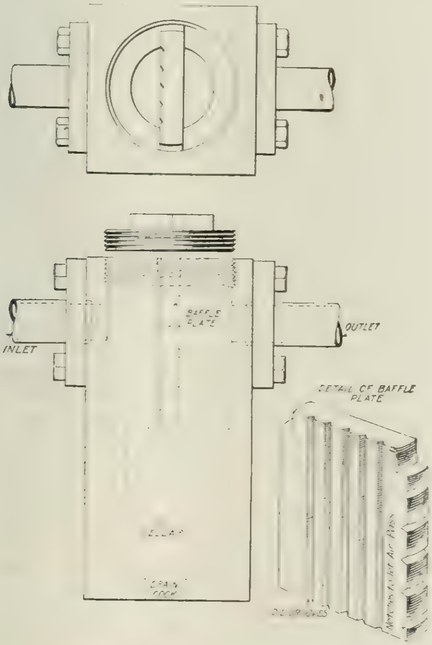


FIG. 1. DETAILS OF OIL TRAP FOR AIR LINE

"What causes those explosions, J. R.?"

"Well, Woods, to my way of thinking it's due to cylinder oil. This oil will gradually collect in the air line and bottles, and if conditions are just right, the oil will ignite. The majority of air compressors, operating with 1000 lb. pressure, are insufficiently cooled, especially in the matter of an aftercooler. Frequently the air leaves the compressor with a temperature above 200 deg. F. This heat rapidly vaporizes the oil trapped in the bottles and ignites it. There is no doubt that every compressor should have an aftercooler to reduce the temperature of the air as it leaves the high-pressure cylinder. Furthermore, when bottles are used, the air line should have an oil trap.

"The traps we have here were made right in our own shop. I never could induce the big chiefs to buy them, so I figured out a scheme and made them. You all know how they look outside. This sketch (Fig. 1) gives the details. I simply took a piece of square machinery steel, machined both sides and made pipe connections. Then I bored the vertical hole, making it of two diameters as shown, tapping the top for a plug and the bottom for a drain. Next I machined a flat strip of steel, notching the side edges and cutting several grooves in the face toward the inlet. This strip was inserted in the vertical cavity. The air, as it enters the block, must pass around this partition to get out, and so the oil is thrown against the plate and trickles down the grooves to the bottom, where it's drained out every day. It's well to remember that some of the oil used in the compressor will vaporize and pass out with the air. Then if the high-pressure air is not passed through an aftercooler, some of the oil vapor will be carried into the bottles, where it will cool and liquefy. The separator cannot eliminate oil in a gaseous condition. Therefore, two things are necessary to prevent explosions—an aftercooling of the air and a good separator."

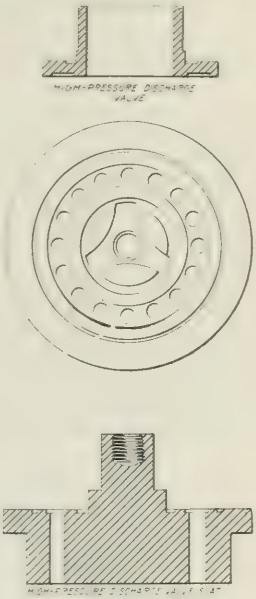

HIGH-PRESSURE DISCHARGE VALVE
HIGH-PRESSURE DISCHARGE VALVE SEAT

FIG. 2. DISK TYPE OF DISCHARGE VALVE

"Mr. Egan," said Woods, "I've heard that it was a good idea to have the air charge hot. Is that right?"

"There is one time when it would seem right to use hot injection air—that is, on very heavy loads. On low loads the entire engine cools off. The water jacket, since it absorbs practically the same amount of heat, actually absorbs a larger percentage of the heat than on full load. So the compression charge in the engine cylinder doesn't reach as high a temperature. If the load is very small, the temperature may be too low to ignite the oil. This is aggravated by the chilling effect of the injection air."

"How's that, chief? I can't see how the air would chill the combustion chamber."

"Well, consider the facts. The charge of fuel in the fuel valve is small. There is nothing to prevent the air from blowing direct into the cylinder. In blowing through the nozzle in a practically unbroken stream, the air expands and, in so doing, becomes comparatively cold. This has a chilling effect on the fuel charge and tends also to lower the temperature of the entire charge of compressed air in the engine cylinder. Under such conditions, an engine will probably misfire and have a smoky exhaust. If we could raise the temperature of the air-injection charge, the chilling effect would be eliminated, or at least reduced."

"How about full load, J. R.?" Kelly inquired.

"On full load the air should not be hot. First, there is a danger of getting the oil hot, and if it is a gas oil, it may explode in the fuel-valve cavity. Again, hot air has a larger volume than cold air under equal pressure, which means that it requires more work to compress a given weight of hot air than of cold air. This causes excessive compressor work or too small a weight of air injected. I'll choose having the air charge not above 120 deg. F. One thing the majority of builders neglect is to provide enough coils in the aftercooler."

"How about the amount of compressor-cylinder oil?" The Scotsman asked the question.

"The amount of oil to be used in the compressor varies with different engines. A fair estimate with a three-stage compressor is about these values: One drop per minute to the low-pressure cylinder, one drop per minute to the intermediate-pressure cylinder, and five drops per minute to the high-pressure cylinder."

"Why do you feed more oil to the high-pressure than to the low-pressure cylinder? The low pressure is lots the biggest, and I'd think it ought to have a lot more oil." Woods raised this objection.

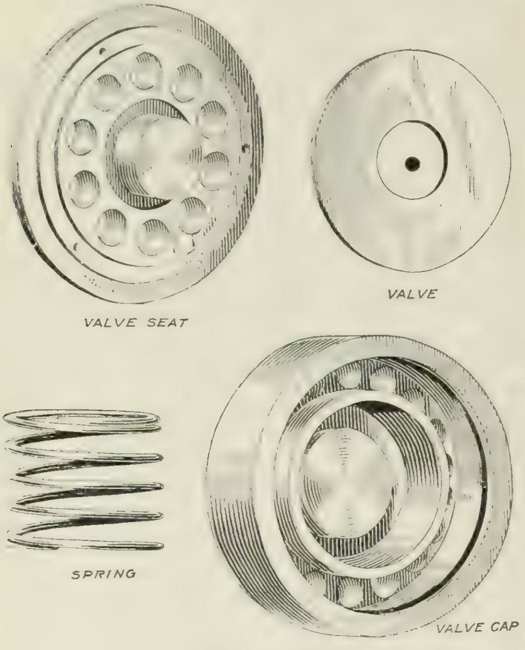


FIG. 3. DETAILS OF POPPET VALVE

"The low-pressure cylinder is working against very low pressure, and the temperature in the cylinder is very low. No oil is vaporized, and all is used in lubricating only. When we get to the high-pressure, we find the temperature in the cylinder is high and the oil will vaporize to some extent. It's necessary to provide for this, and at the same time to have a good film of oil on the piston to prevent sticking. One thing, boys, don't be too generous with oil. Never use any more than just enough. Also, be sure that the wear on the connecting-rod brasses doesn't let the piston clearance become too great. A considerable loss in compressor efficiency can occur with only a few thousandths wear on the brasses."

"Chief, how about the valves? Do you like the plug-hat kind or the flat round one?"

"By the flat round one, Kelly, I suppose you mean the disk valve shown in Fig. 2. This is fine for a slow-speed compressor; but if the speed is above 150 revolutions, it tends to bend at the edges rather than rise, which in time causes the disk to crack. It is just as good as most valves.

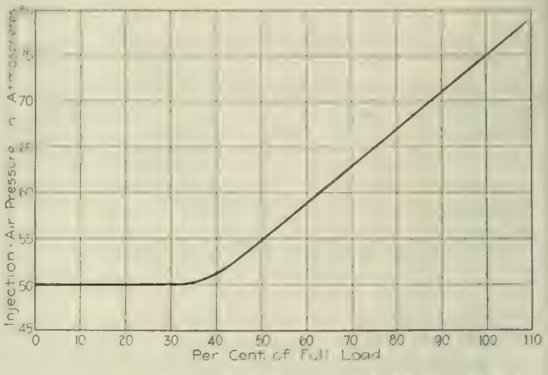


FIG. 4. RELATION OF INJECTION-AIR PRESSURE TO LOAD ON ENGINE

"Fig. 3 is a plug-hat or poppet valve. This sketch shows the valve seat and cage as well. Its chief difficulty is the tendency for the brim, as you'd call it, to break away from the crown. In several makes of engines using this type of valve, the same trouble occurs. We have tried all kinds of steel for the valves—nickel steel, high-speed tool steel, machinery steel and what not. The best kind I've found is vanadium steel carefully oil-treated. It seems to have the necessary strength and is tough.

"When grinding compressor valves, use more than good care. Use only the finest of rotten-stone. Even emery is too coarse for so delicate a valve seat. Also, test the relief valve on the intercooler every month to see that it doesn't stick. Now, boys, is there anything you want to ask?"

"Well, J. R.," Woods spoke up, "what injection-air pressure ought we to carry?"

"Practically all engines operate to best advantage with approximately the same pressures. The blueprint (Fig. 4) hanging on the wall gives a curve that shows the pressures to be carried at various loads on our engines. I like to see this followed as close as possible since the values have been tried out and are about right."

It is reported that ten of the largest locomotives in the world are to be built for the Virginian R.R. Each weighs 449 tons with the tender, has a high-pressure cylinder 30 in. in diameter, low-pressure cylinder 48 in. in diameter, and is equipped with 20 driving wheels. Each locomotive develops 5040 horsepower.

Finish the job with the Victory Liberty Notes.

Comparison of the New A. S. M. E. Boiler Code and the Massachusetts Boiler Rules

In THIS article an attempt will be made to point out the chief differences between the rules of the new A. S. M. E. Code and those of the State of Massachusetts, for the construction of boilers. A direct comparison is difficult in some respects, owing to the fact that the Massachusetts rules are divided into three parts, the first and second affecting old boilers and the second and third, new boilers. There is no clear-cut division between power boilers and heating boilers in the Massachusetts rules, as is the case with the Code. In fact, heating boilers are almost entirely neglected in the Massachusetts rules. No attention will be given to the rules for old boilers as provided for in either set of rules, and heating boilers, as treated in the Code, will not be particularly referred to.

A feature that makes reference to the Massachusetts rules cumbersome is the method of dividing them into parts and sections, the paragraphs in each section being numbered consecutively, beginning with 1 each time. In the Code the paragraphs are numbered in order throughout the book. In an attempt to overcome the difficulty of referring to the Massachusetts rules, the references will be given in the following manner: After the letter M there will be given the page and paragraph numbers; thus, M-51-6 will refer to page 51 and the sixth paragraph on that page of the 1918 edition of the Massachusetts rules. The references to the Code will be the letter C followed by the paragraph number referred to; thus, C-51 indicates that paragraph 51 of the Code is referred to.

Cast iron is evidently intended to be prohibited as a material for the construction of steam boilers to be operated at pressures in excess of fifteen pounds, except for headers, cross-boxes and such parts, by either set of rules. The Massachusetts rules distinctly state this to be a fact (M-10-1), but the Code does not clearly bring out this point. In fact, from C-9 it would appear that a cast-iron boiler might be constructed under the Code rules for any pressure up to 160 lb. The Massachusetts rules permit the use of cast-iron mud drums for boilers up to 160 lb. pressure (M-51-7), while the Code requires all such drums, except those on heating boilers, to be of wrought or cast steel (C-10). The shearing strength allowable for rivets under the Massachusetts rules (M-10-5) is less than in the Code, except for iron rivets in single shear. The minimum safety-valve capacity required under the Massachusetts rules is based on the working pressure and the grate area to be served (M-13-2).

While the Massachusetts rules indicate that when conditions exceed those on which the table for safety-valve capacities are based, a formula must be used, given in M-18-4, to determine the valve capacity required, there is no very definite relation between the amount of steam to be handled and the discharge capacity of the valve, to determine when the formula must be applied. The particular condition that may be exceeded is in regard to the amount of water that may be evaporated per square foot of grate surface per second. The formulas given are based on an assumed discharge area, equivalent to one-eighth the nominal valve area for flat-seated valves and one-eleventh the nominal valve area for bevel-seated valves, without regard to what the actual lift may be.

This leaves the matter entirely to the judgment of the inspector with no very definite means to determine when it is necessary to depart from the values given in the table. It is likely that no two inspectors, except at a joint inspection, could agree on the proper procedure in a given case.

The Code minimum requirements for safety valves are based on the heating surface to be served (C-274) and the further requirement that the rise in pressure above the maximum allowable working pressure shall not be more than 6 per cent. (C-270). The Massachusetts rules limit the diameter of safety valves to a maximum of 5 inches (M-19-9), while the Code has no such limit. The Massachusetts rules (M-19-9) require that a lifting gear for safety valves be supplied, which will lift the valve from its seat one-eighth the diameter of the valve when the pressure under the valve is 75 per cent. of the pressure at which it is set. The Code requirements for lifting gear for safety valves is that it must be capable of lifting the valve from its seat one-sixteenth of an inch when there is no pressure on the valve (C-282).

Fusible plugs are required by law in Massachusetts (M-19-10), but their use is optional so far as the Code rules are concerned (C-428). The Massachusetts rules specify that check valves must be supplied on the return pipes to heating boilers (M-25-24 and M-25-25), while the Code has no specific requirements for such fittings on the return pipes to heating boilers. The limit for the hydrostatic pressure test in the Massachusetts rules (M-28-1) is given as 1¼ to 1½ times the maximum allowable working pressure; in the Code (C-329), 1½ times the working pressure is required with an upset limit of not over 6 per cent. above this amount.

The material specifications as given in the Massachusetts rules are very meager as compared with the Code. The Massachusetts rules specify two grades of steel for shells, etc.—"firebox" and "extra-soft." The only difference in the chemical characteristics specified for firebox steel as given in the Code (C-25) and the Massachusetts rules (M-41-3), is that for such steel made by the basic process the phosphorus content may be 0.005 per cent. more in the case of the Code than for the Massachusetts rules. This difference, however, has been removed by a ruling of the Massachusetts authorities issued Dec. 2, 1918, making this requirement the same as the Code. There is no extra-soft grade of steel specified in the Code rules, although a steel of lower tensile strength than either flange or firebox may be used as provided for in C-28.

In the Massachusetts rules rivets are specified to be made of extra-soft steel (M-42-4); the rivet material required by the Code (C-41) differs from this in chemical characteristics only in that the sulphur content may be 0.045 per cent. instead of 0.04 per cent., as required by the Massachusetts rules. The physical characteristics for steel plate as given in M-42-5 and C-28 differ slightly as regard to tensile-strength range and the requirements for elongation.

The bend test for material over three-fourths of an inch in thickness as called for in the Massachusetts rules (M-43-7), is different for similar tests required for the same material under the Code rules (C-30). The specifications for cast iron and cast steel given in the Massachusetts rules (M-50-4 and M-50-5) merely refer to the ultimate strength of the material, while the specifications for such material in the Code rules are very complete. However, M-88-53a specifies that steel castings must conform to Class B grade of the American Society for Testing Materials. A specification for the physical characteristics of stay-bolt material is given in the Massachusetts rules (M-79-36), but it is not required that such material be used for stay-bolts unless certain special stress allowances are desired.

No specifications for tubes or tube material are given in the Massachusetts rules, while the Code (C-20-21 and 22, also C-164 to 178) goes into the subject in a very complete manner. The efficiency of ligaments between the tube holes that may be placed in the shell of the drum of a boiler as given in the Massachusetts rules (M-58-3) is different from those required in the Code rules (C-193). The Massachusetts rules do not permit a longitudinal joint over twelve feet long on the shell of a horizontal-tubular boiler, vertical-tubular boiler or a locomotive-type boiler (M-62-9); the Code specifies this restriction only for longitudinal joints on the horizontal-tubular type of boiler and where the joint is of the lap type; butt joints of any length may be used if the material is tested in the direction of maximum stress (C-190).

The required thickness for butt straps for plates of different thicknesses are the same in both sets of rules with the single exception that for 1-in. plate the Code requires $\frac{11}{16}$-in. straps and the Massachusetts rules $\frac{3}{4}$-in. straps for this plate thickness (C-19 and M-63-13). The pressures allowed on dished heads are different, the requirements for such heads being given at C-195 and M-64-16. The pitches allowed for stay-bolts on flat surfaces are different in the two sets of rules, although not radically so; the requirements are given at M-66-21, M-68-22, M-69-23 and C-199, C-204.

In determining the area on the segment of a head to be stayed, the Massachusetts rules deduct the area between the bounding surface and lines drawn two inches above the tubes and three inches from the shell (M-72-28). The Code specifies the fixed distance of two inches above the tubes in making such calculations, but varies the distance allowed from the shell, depending on the thickness of the head, the radius of the turn of the flange and the pressure for which the boiler is constructed (C-214). The stresses allowed on stays by the Code rules (see Table 5 on page 59) are somewhat higher than the corresponding stresses allowed by the Massachusetts rules (M-78-35). However, considering that the Code specifies the quality of the material permitted to be used for such purpose, the difference in this respect between the two sets of rules is not of moment so far as safety is concerned. In the Massachusetts rules where hollow stays are used, if the hole in the stay is not over $\frac{3}{16}$ in. in diameter, the bolts are considered as solid for the purpose of calculating their strength (refer to part of paragraph 39 at top of page 83 in the Massachusetts rules). In the Code the net cross-sectional area is to be used in all such cases (C-220).

The Massachusetts rules require a manhole below the tubes in horizontal-tubular boilers only when the diameter is 60 in. or more (M-89-60); the Code requires such openings in boilers of this type when the diameter is 48 in. or over (C-264).

The Massachusetts rules do not allow an internal pipe to be fitted to a connection to which a safety valve is attached (M-92-1). The Code permits such internal pipes with certain restrictions (C-290).

The Massachusetts rules require that a safety valve be applied to a superheater if it can be shut off from the boiler to which it is attached, and that such safety valve be placed near the inlet to the superheater (M-93-2). The Code rules require a safety valve on all superheaters, and this valve must be located near the outlet from the superheater (C-288).

Main outlet valves must be extra-heavy by the Massachusetts rules when the working pressure is over 100 lb. (M-93-4); the Code rules have a similar requirement, but specify the limiting pressure as 125 lb. (C-302). Two valves or a valve and a cock must be applied to the blowoff connection, under the Massachusetts rules, when the pressure is over 100 lb. (M-96-18); the pressure limit for similar requirements under the Code rules is 125 lb. (C-311).

The Massachusetts rules do not allow the use of automatic water gages under any circumstances (M-98-27), while such fittings are permitted under the Code rules if constructed to comply with certain requirements (C-292 and C-427). The ogee construction at the bottom of the water-leg is prohibited by the Massachusetts rules (M-98-1), while the Code rules permit its use (C-13).

While the chief differences existing between the Massachusetts rules and those of the Boiler Code of the American Society of Mechanical Engineers have been given, in cases where both sets of rules treat the same details, the Code rules are evidently much more complete than are those of Massachusetts. This is, of course, not to the discredit of the Board of Boiler Rules of Massachusetts, for the Code Committee made complete use of the Massachusetts rules and many others in its attempt to make the Code rules comprehensive.

The Massachusetts rules are not only silent on the question of gage and material for boiler tubes, but lack any reference to flues or furnaces, except of the stay-bolted type as used in the vertical-tubular type of boiler. The question of braced and stayed surfaces is also not treated in a sufficiently broad manner in the Massachusetts rules, while the treatment of this subject in the Code is excellent. The treatment of safety valves is likewise too meager in the Massachusetts rules. While complete uniformity is desirable, considerable difficulty would be avoided for the inspector and the boiler manufacturer and a much wider and more competitive market for the purchase of boilers would be afforded the steam user in the State of Massachusetts if the two sets of rules could be harmonized with respect to the differences pointed out in this article.

Two things sought after in cooling-tower design are to present a large surface of water to the air and to provide for bringing constantly into contact with this surface the largest possible volume of new air with the least possible expenditure of energy.

They did not quit with four drives. We'll finish the Fifth Loan.

Proportioning Fuel Economizers

By A. B. CLARK

Shows how economizers may be proportioned to give desired gas and water temperatures. The data presented show the advantages of contraflow over parallel flow of water and gas.

As economizers are being used to a much greater extent than formerly, a discussion on the characteristics of this class of apparatus may be of interest. Assume that an economizer is to be so proportioned that the combined efficiency of both boiler and economizer will be 80 per cent., with a coal containing 10,000 B.t.u. per lb. The steam has a pressure of 250 lb., gage, and 250 deg. F. of superheat, the feed water entering the economizer at 100 deg. F. Under these conditions the heat contained in one pound of steam will be 1340 B.t.u. As the feed water contains 68 B.t.u., the heat given by boiler and economizer is 1272 B.t.u. per pound of steam. As the efficiency is 80 per cent., 8000 B.t.u. of the 10,000 B.t.u. in each pound of coal is used, and the evaporation is 8000 ÷ 1272 = 6.3 lb. of water per pound of coal.

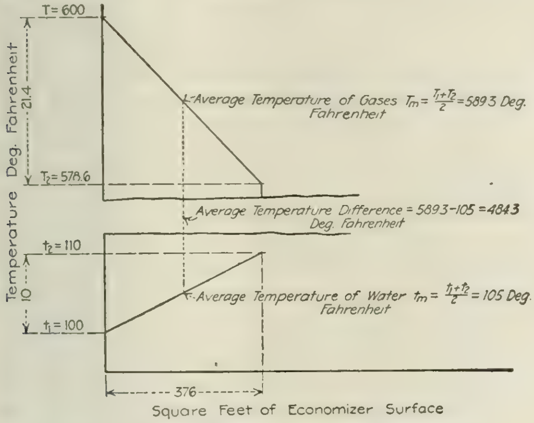

T=600
21.4
T_2=578.6
Temperature Deg. Fahrenheit
Average Temperature of Gases $T_m=\frac{T_1+T_2}{2}$=589.3 Deg. Fahrenheit
Average Temperature Difference = 589.3−105 = 484.3 Deg. Fahrenheit
t_2=110
10
t_1=100
Average Temperature of Water $t_m=\frac{t_1+t_2}{2}$ = 105 Deg. Fahrenheit
376
Square Feet of Economizer Surface

FIG. 1. GAS AND WATER TEMPERATURES IN PARALLEL-FLOW SYSTEM

Allowing for excess air and infiltration of air, there will be about 12.25 lb. of flue gases produced per pound of coal burned. Now, the heat given up by the flue gases must equal the heat absorbed by the water, if the radiation loss is neglected; that is, the product of the specific heat, weight and drop of temperature of the flue gases must equal the product of the specific heat, weight and rise of temperature of the water.

Let t_g represent the drop of temperature of the flue gases and t_w represent the rises of temperature of the water. Then

$$0.24 \times 12.25 \times t_g = 1 \times 6.3 \times t_w \text{ and } \frac{t_g}{t_w} = \frac{1 \times 6.3}{0.24 \times 12.25} = 2.14$$

This means that for every degree of increase of temperature of the 6.3 lb. of water the 12.25 lb. of flue gases will drop 2.14 deg. in temperature.

The weight of water passing through the economizer is taken to be 100,000 lb. per hour. It is assumed that the boiler is capable of evaporating this amount and that under these conditions the gas temperature leaving the boiler will be 600 deg. F. The water and gases may both flow in the same direction, called parallel flow, or in opposite directions, according to the so-called contraflow arrangement. The first consideration will be with the gases and the water flowing in the same direction, in which case the hottest gases meet the coldest water, as shown in Fig. 1.

TABLE I. PARALLEL FLOW, WATER ENTERING AT 100 DEG. F.

T_1	T_2	Tm	t_1	t_2	tm	Tm	tm	H	100,000 × 10 B.t.u.	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	578.6	589.3	100	110	105	484.3	2,663	1,000,000	376	376
578.6	557.2	567.9	110	120	115	452.9	2,491	1,000,000	401	777
557.2	535.8	546.5	120	130	125	421.5	2,318	1,000,000	431	1,208
535.8	514.4	525.1	130	140	135	390.1	2,145	1,000,000	466	1,674
514.4	493.0	503.7	140	150	145	358.7	1,973	1,000,000	507	2,181
493.0	471.6	482.3	150	160	155	327.3	1,800	1,000,000	555	2,736
471.6	450.2	460.9	160	170	165	295.9	1,627	1,000,000	615	3,251
450.2	428.8	439.5	170	180	175	264.5	1,455	1,000,000	687	3,938
428.8	407.4	418.1	180	190	185	233.1	1,282	1,000,000	780	4,718
407.4	386.0	396.7	190	200	195	201.7	1,109	1,000,000	901	5,619
386.0	364.6	375.3	200	210	205	170.3	937	1,000,000	1,067	6,686
364.6	343.2	353.9	210	220	215	138.9	764	1,000,000	1,309	7,995
343.2	321.8	332.5	220	230	225	107.5	591	1,000,000	1,692	9,687

On examination of Fig. 1 it is easily seen that the average temperature difference between the water and gases for the part of the economizer under consideration is 484.3 deg. F. Tests made on a number of economizers show that the rate of heat transfer from gas to water is about 5.5 B.t.u. per square foot of surface per hour per degree temperature difference between

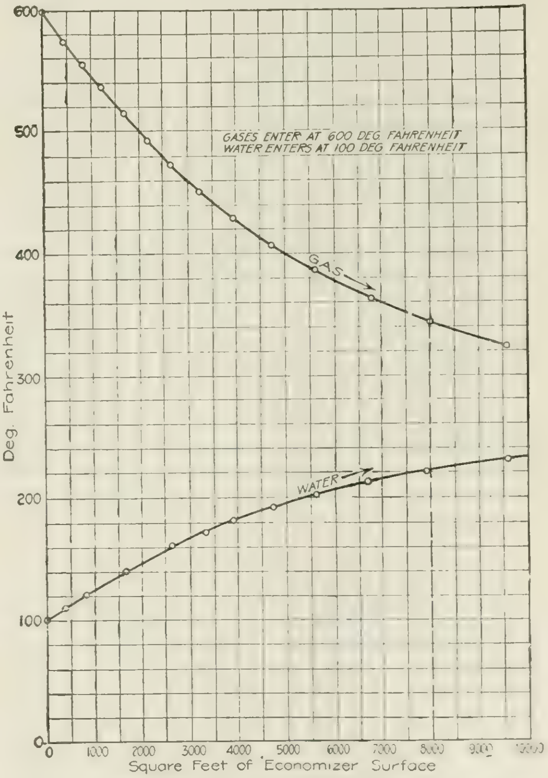


FIG. 2. CHARACTERISTICS OF ECONOMIZER WITH GASES AND WATER FLOWING IN SAME DIRECTION

the gases and the water, when the gas passage through the economizer is proportioned for a flow of 5000 lb. of gas per hour per square foot of area. It will be reduced to 4 B.t.u. per sq.ft. if the flow is reduced to 3000 lb. per hour and in proportion between these two points.

Using the higher value for calculation, it is found that the heat transfer H per square foot per hour is $5.5 \times 484.3 = 2663$ B.t.u. Therefore, the surface required to raise 100,000 lb. of water through 10 deg. F. is $100,000 \times 10 \div 2663 = 376$ sq.ft. In tabular form this is represented by the first line of Table I. The next step is to take new figures for gas and water temperatures and tabulate as in the remainder of the table. For convenience, the table is based on equal increases of 10 deg. in the feed-water temperature.

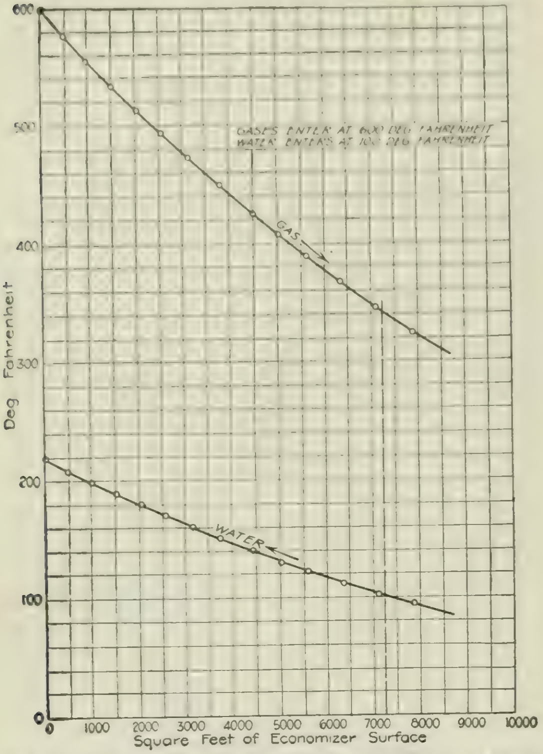


FIG. 3. CHARACTERISTICS OF ECONOMIZER ARRANGED FOR CONTRA-FLOW OF GASES AND WATER

TABLE II. CONTRAFLOW, WATER ENTERING AT 100 DEG F

T_1	T_2	Tm	t_1	t_2	tm	Tm tm	H	100,000 × 10	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	578.6	589.3	220	210	215	374.3	2,078	1,000,000	486	486
578.6	557.2	567.9	210	200	205	362.9	1,996	1,000,000	501	987
557.2	535.8	546.5	200	190	195	351.5	1,933	1,000,000	517	1,504
535.8	514.4	525.1	190	180	185	340.1	1,870	1,000,000	535	2,039
514.4	493.0	503.7	180	170	175	328.7	1,833	1,000,000	553	2,592
493.0	471.6	482.3	170	160	165	317.3	1,745	1,000,000	573	3,165
471.6	459.2	460.9	160	150	155	305.9	1,682	1,000,000	594	3,759
450.2	428.8	439.5	150	140	145	294.5	1,620	1,000,000	617	4,376
428.8	407.4	418.1	140	130	135	283.1	1,557	1,000,000	642	5,018
407.4	386.0	396.7	130	120	125	271.7	1,494	1,000,000	669	5,687
386.0	364.6	375.3	120	110	115	260.3	1,432	1,000,000	698	6,385
364.6	343.2	353.9	110	100	105	248.9	1,369	1,000,000	730	7,115
343.2	321.8	332.5	100	90	95	237.5	1,306	1,000,000	766	7,881

The data in Table I are plotted in Fig. 2. It is readily seen how the surface must be increased for a given rise of the water temperature as the temperatures of the water and gas approach each other. As pointed out previously, the efficiency of the boiler and the economizer is 80 per cent. The ashpit loss will be about 3 per cent. and the unaccounted for losses, radiation, etc., will account for about 3.5 per cent. Therefore the flue-gas loss will be 13.5 per cent., or 1350 B.t.u. per pound of coal.

Flue gases from a coal of the grade assumed will contain about 0.5 lb. of water in the form of superheated steam; therefore, as the total weight of gases is 12.25 lb. per pound of coal, the gases will weigh 11.75 lb. and the water vapor 0.5 lb. The problem now is to find the temperature of the escaping gases. Assuming that the air entering the boiler is at a temperature of 70 deg. F., the temperature of the escaping gases may be found from the equation,

$$11.75 \times 0.24\ (t - 70) + 0.5 \times 0.48\ (t - 212) + 0.5 \times 970.4 + 0.5\ (212 - 70) = 1350$$

from which $t = 340$ deg. F. Now referring to Fig. 2, it will be found that for a final gas temperature of 340 deg. the surface required is 8000 sq.ft. Also, it will be observed that the feed-water temperature will be 220 deg. F., a rise in temperature of 120 deg. Fahrenheit from the assumed initial temperature. The return in heat units per pound of coal as fired is $6.3 \times 120 = 756$ B.t.u., or a return of 7.56 per cent. on a heating value of 10,000 B.t.u.

TABLE III PARALLEL FLOW, WATER ENTERING AT 150 DEG F

T_1	T_2	Tm	t_1	t_2	tm	Tm tm	H	100,000 × 10	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	577.7	588.8	150	160	155	433.8	2,386	1,000,000	419	419
577.7	555.4	566.6	160	170	165	401.6	2,209	1,000,000	452	871
555.4	533.1	544.2	170	180	175	369.2	2,031	1,000,000	492	1,363
533.1	510.8	521.9	180	190	185	336.9	1,853	1,000,000	539	1,902
510.8	488.5	499.6	190	200	195	304.6	1,675	1,000,000	597	2,499
488.5	466.2	477.3	200	210	205	272.3	1,498	1,000,000	667	3,166
466.2	443.9	455.0	210	220	215	240.0	1,320	1,000,000	757	3,923
443.9	421.6	432.7	220	230	225	207.7	1,142	1,000,000	875	4,798
421.6	399.3	410.4	230	240	235	175.4	965	1,000,000	1,036	5,834
399.3	377.0	388.2	240	250	245	143.2	788	1,000,000	1,270	7,104
377.0	354.7	365.8	250	260	255	110.8	609	1,000,000	1,642	8,746
354.7	332.4	343.5	260	270	265	78.6	432	1,000,000	2,315	11,061

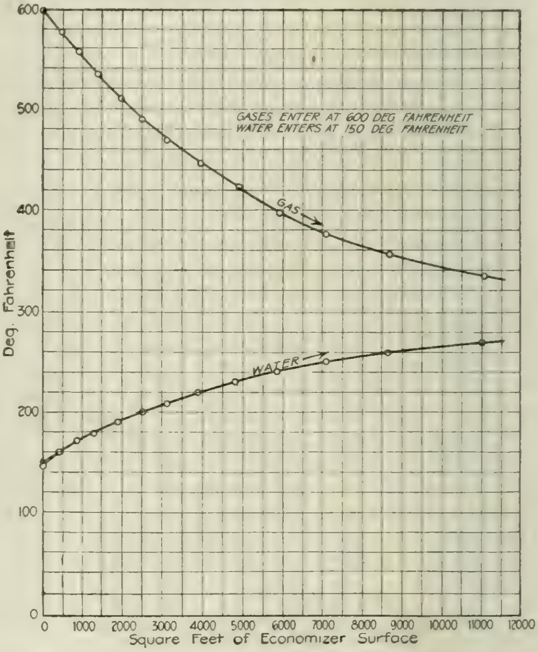


FIG. 4. PARALLEL-FLOW ARRANGEMENT, WATER ENTERING AT 150 DEG. F.

The contraflow method, in which the hottest gases meet the hottest water, will next be discussed. As before, the heat given up by the gases must equal the heat given to the water, assuming no radiation, etc. Therefore, the rise in temperature of the feed water for a given drop of gas temperature will be the same as in the case of parallel flow, but the difference will lie in the amount of surface required to bring about these conditions. The tabulation will therefore start with gases entering the economizer at 600 deg. F. and the temperature of the water leaving at 220 deg. F., as given in Table II.

Fig. 3 shows Table II in graphical form, and a study of this diagram shows that to obtain a final gas temperature of 340 deg. F. it is necessary to install an economizer surface of 7300 sq.ft., which is just 700 sq.ft. less than for an economizer connected for parallel flow. It is easily seen from the shape of the two diagrams, Figs. 2 and 3, that as the temperature of the gases and water approach each other, the surface required becomes very large for a given increase of water temperature in the case of the parallel flow as against contraflow. The advantage of the contraflow system becomes more apparent the larger the economizer.

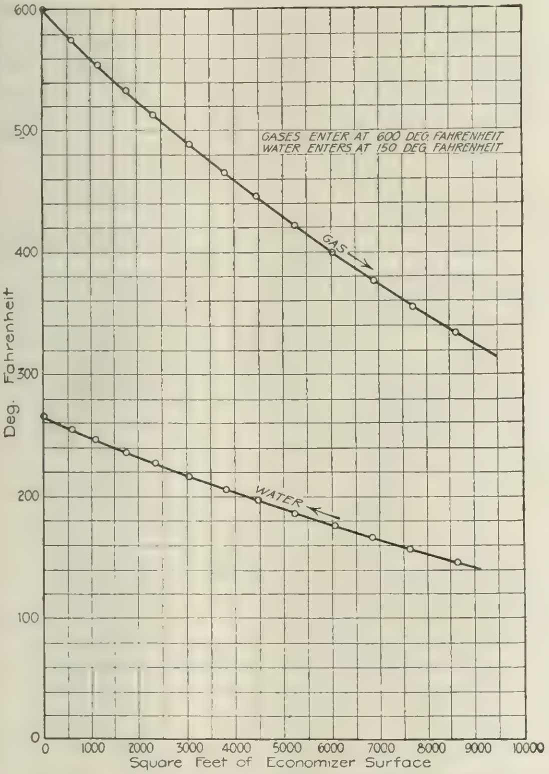


FIG. 5. CONTRA-FLOW ARRANGEMENT, WATER ENTERING AT 150 DEG. F.

TABLE IV. CONTRAFLOW, WATER ENTERING AT 150 DEG. F

T_1	T_2	Tm	t_1	t_2	tm	Tm − tm	H	100,000 × 10	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	577.7	588.8	265	255	260	328.8	1,808	1,000,000	553	553
577.7	555.4	566.6	255	245	250	316.6	1,741	1,000,000	574	1,127
555.4	533.1	544.2	245	235	240	304.2	1,673	1,000,000	598	1,725
533.1	510.8	521.9	235	225	230	291.9	1,605	1,000,000	623	2,348
510.8	488.5	499.6	225	215	220	279.6	1,538	1,000,000	650	2,998
488.5	466.2	477.3	215	205	210	267.3	1,470	1,000,000	680	3,678
466.2	443.9	455.0	205	195	200	255.0	1,403	1,000,000	713	4,391
443.9	421.6	432.7	195	185	190	242.7	1,335	1,000,000	749	5,140
421.6	399.3	410.4	185	175	180	230.4	1,267	1,000,000	789	5,929
399.3	377.0	388.2	175	165	170	218.2	1,200	1,000,000	833	6,762
377.0	354.7	365.8	165	155	160	205.8	1,132	1,000,000	883	7,645
354.7	332.4	343.5	155	145	150	193.5	1,064	1,000,000	940	8,585

The next question of interest is to determine just how much larger an economizer must be so that the same efficiency may be obtained with water entering at, say, 150 deg. F. as against the 100 deg. F. assumed in the previous calculations.

As the water is to enter at 150 deg. instead of 100 deg. F., the evaporation per pound of coal will be increased, but not the efficiency. Therefore, the fall of gas temperature for a given rise of water temperature must be refigured. The heat available is 8000 B.t.u., as before, but the heat given to 1 lb. of water is $1340 - 118 = 1222$ B.t.u. Therefore, the evaporation is $8000 \div 1222 = 6.55$ lb. per pound of coal. The ratio of the change of temperatures is $\frac{t_g}{t_w} = \frac{1 \times 6.55}{0.24 \times 12.25} = 2.23$.

With this information, the tabulation shown in Table III for the parallel-flow arrangement may be made.

Fig. 4 is the graph of Table III and shows that to reduce the temperature of the gas at the outlet from the economizer to 340 deg. F., as before, the surface must be increased to about 10,500 sq.ft., which is more than 30 per cent. greater than for the case shown in Fig. 2. If, however, the same size of economizer were used, the gas temperature at the outlet from the economizer would be raised to about 363 deg., with a corresponding loss due to the flue gases of about 1420 B.t.u., or 14.2 per cent. of the heat in the fuel, an increase of 0.7 per cent.

In Table IV will be found the tabulation corresponding to the case of the contraflow method of arrangement. In Fig. 5, the graph of Table IV, it is seen that the economizer surface required to bring the final temperature of the gas to 340 deg. F. is 8300 sq.ft. This is about 1000 sq.ft. more than is shown in Fig. 3, or an increase of nearly 14 per cent. If the surface is not increased, the gas-outlet temperature will be about 363 deg., as before, with an increased loss of 0.7 per cent. in the flue gases.

Any particular set of conditions can be assumed and the results can be easily worked out by the methods given, and the graphs will show reliable information as to just what to expect.

Buyer's Acceptance of Engine

A gasoline engine was sold under an agreement that it might be returned by the buyer if found to work unsatisfactorily after thirty days' trial. But he was induced to retain it beyond that time by the seller on representations that trouble which developed in operating the engine was due simply to the fact that it was new, the parts were tight, and that it would not operate well until used for some time. Under these circumstances it was decided by the Wisconsin Supreme Court in the recent case of Barta vs. Blahnik, 170 Pacific Reporter, 281, that it was not open to the seller to recover the agreed purchase price, as against the buyer's expressed desire to rescind the purchase because the engine was not as represented, on a theory that the buyer's retention of the equipment for more than thirty days' amounted to a final acceptance of it.

The Electrical Study Course—Current in the Inductances of a Three-Wire Generator

Discusses the manner in which the direct current of the neutral wire is superimposed upon the alternating current that normally flows through the balancing inductances.

THE direction of the currents in the inductances used with a three-wire generator depends on the relative values of the alternating and direct currents through them. In any event the current flowing is a combination of a direct and an alternating one, and its value will therefore be changing from instant to instant. Consequently, we shall have to investigate instantaneous values instead of continuous ones. To study the conditions that exist, let us refer to Figs. 1 to 4. In them C represents the commutator and S the slip rings of a two-pole three-wire generator, and L_1 and L_2 the inductances used in connection with it to furnish energy to a three-wire system over the mains A, N and B. Let us assume that the maximum exciting current taken by the inductances L_1 and L_2 is 5 amperes and that the inductances have 100 turns each. Then the maximum ampere-turns (amperes times turns) is 5 x 200 = 1000; that is 1000 ampere-turns are required to set up, through the core, a magnetic field that will generate a counter-voltage in the coils almost equal to the applied volts across the brushes (220 volts). It will be remembered that in the last lesson it was shown how there was only about one or two volts difference between the counter-voltage induced in the inductances and the voltage across the direct-current brushes, when the armature is in the position, Fig. 1, and that this difference between the applied volts and the counter-volts caused a current to flow that magnetized the core.

If 1000 ampere-turns are sufficient to set up a magnetic field in the core that will cause to be generated a back pressure in coils L_1 and L_2 almost equal to the applied volts, then if the ampere-turns are increased slightly the counter-pressure will become greater than the applied volts and the inductances L_1 and L_2 will supply power to the system instead of taking power from the armature. This is just what happens in a three-wire generator, as will be shown in the following:

Assume in Fig. 1 that the load on the system is unbalanced so that 5 amperes is flowing in the neutral. For the position of the armature shown in the figure, up to the point where the unbalanced current is capable of supplying all the ampere turns, the current in the neutral will flow through L_2 to the negative point in the armature through the armature winding to the positive brush. Now if the 5 amperes flows through L_2 to the negative brush, it will be in the same direction as the

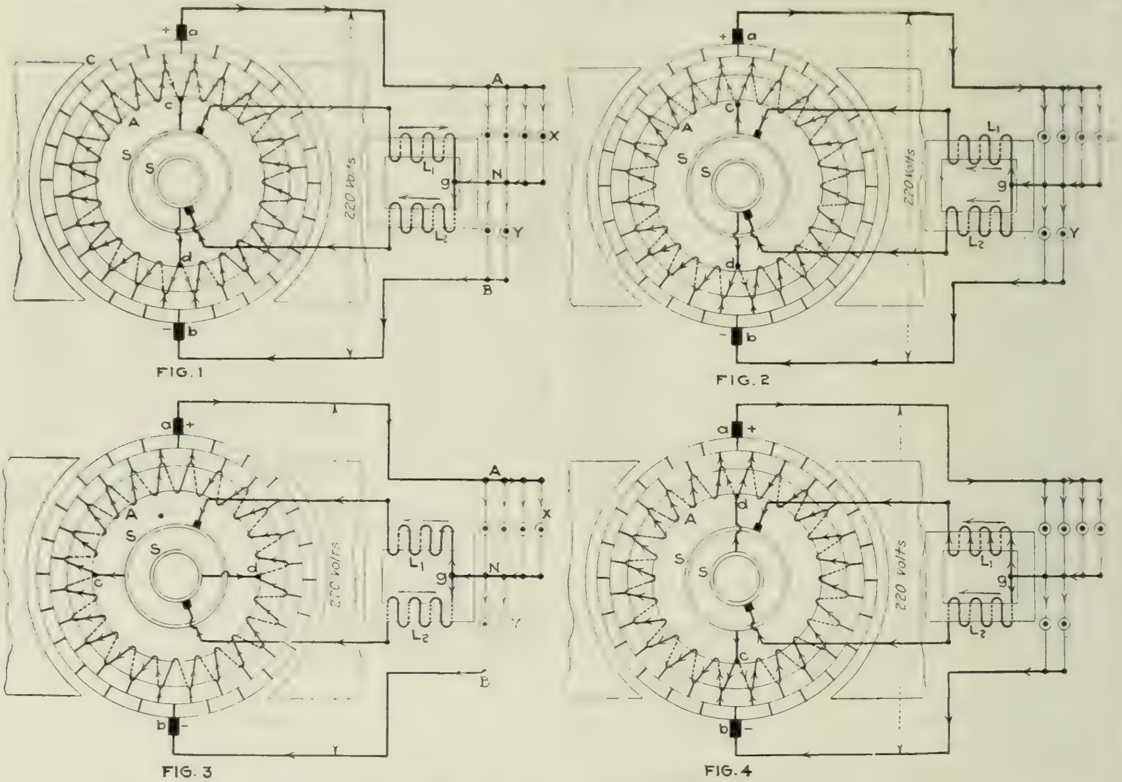


FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIGS. 1 TO 4. SCHEMATIC DIAGRAMS OF THREE-WIRE GENERATORS CONNECTED TO A LOAD magnetizing current flowing from *c* to *d*, consequently will increase the ampere-turns by the value of the current in the neutral times the turns in L_2, or in this case 5 × 100 = 500. The total ampere-turns required are 1000; then, if 500 ampere-turns are supplied by the current in the neutral, flowing through L_2, only 1000 — 500 = 500 will have to be supplied by the current flowing from *c* to *d* through L_1 and L_2. The magnetizing current will equal the ampere-turns divided by the turns in L_1 and L_2, or 500 ÷ 200 = 2.5 amperes. That is, with 5 amperes flowing in the neutral and through L_2, only 2.5 amperes will flow from *c* to *d*. This will give 2.5 amperes in L_1 and 2.5 + 5 = 7.5 amperes flowing in L_2. The ampere-turns supplied by L_1 equal 2.5 × 100 = 250 and those in L_2 = 7.5 × 100 = 750 or a total of 250 + 750 = 1000, which is correct.

If the current in the neutral was increased to 10 amperes and the total flowed through L_2, then this inductance would be supplying 10 × 100 = 1000 ampere-turns, or the total magnetizing current. Therefore no current will flow from *c* to *d*, but the counter-voltage across L_1 will now be approximately 110 volts since the magnetic field set up by L_2 also passes through L_1. The counter-voltage in L_2 is also approximately 110 volts, and this is just as it should be, since at the instant shown in Fig. 1, 220 volts exists between brush *a* and the negative point *d* in the armature winding, 110 of which is absorbed in causing the current to flow through the lamps between *A* and *N*, and the remaining 110 volts is used up in causing the neutral current to flow through L_2 against its ohmic resistance and counter-voltage. Increasing the load 10 amperes between *A* and *N* over that between *N* and *B* has caused slight unbalancing of the voltage, so that at the instant in question the voltage across *A* and *B* has decreased to a point where it is just equal to the counter-voltage in L_1; then an increase in ampere-turns in L_2, due to a further unbalancing of the load, will cause the back pressure in L_1 to be higher than the voltage between *A* and *N*, and L_1 will begin to act as a generator to supply power to the load between *A* and *N*.

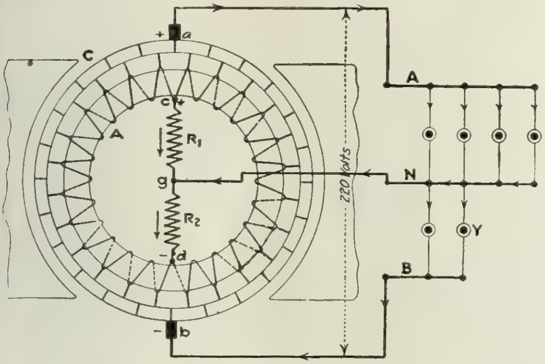


FIG. 5

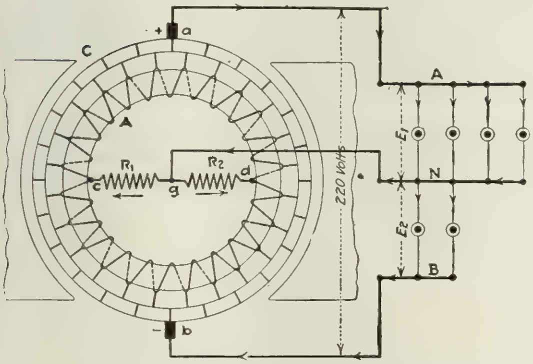


FIG. 6

FIGS. 5 AND 6. THREE-WIRE SYSTEM OBTAINED BY RESISTANCES CONNECTED TO TWO-WIRE GENERATOR

The foregoing is just the condition that we had with the balancer sets, when the load was unbalanced to the point where the machine running as a motor was supplying all the losses in the set, the voltage of the other machine was just equal to the voltage across the side of the system it was connected to; with any further unbalancing of the load one-half of the current was supplied from the machine operating as a generator and the other half from the main generator. Similarly, with the three-wire generator, Fig. 1, if the load is increased 10 amperes more, making a total of 20 amperes, 5 amperes of this increase will be supplied from the armature and will pass through L_2 from *g* to *d* and the other 5 amperes will be supplied by L_1 and will flow from *g* to *c* in an opposite direction to the 15 amperes flowing through L_2, as indicated in Fig. 2. Consequently, the 5 × 100 = 500 ampere-turns of L_1 is in opposition to the 15 × 100 = 1500 ampere-turns on L_2, which makes the effective ampere-turns equal to 1500 — 500 = 1000, the same as when 5 amperes flowed from *c* to *d* through L_1 and L_2, or when 10 amperes flowed through L_2 only. Any further unbalancing of the load will continue to divide up equally between L_1 and L_2 and we will have a current flowing in one direction through L_1 and in the opposite direction through L_2.

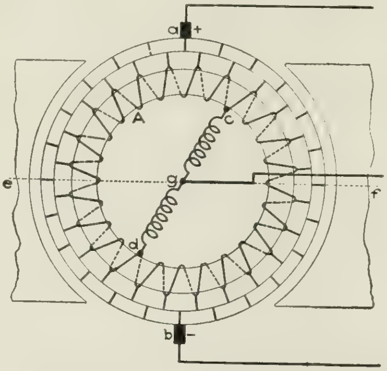


FIG. 7. DIAGRAM OF THREE-WIRE GENERATOR

Next let us investigate the condition that will exist when the armature has made one-quarter revolution, as in Fig. 3. In this position, as we found out in previous lessons, no voltage exists across *c d*. Consequently no magnetizing current will be flowing in L_1 and L_2, and no counter-voltage will be generated in the windings L_1 and L_2. However, 110 volts exists from brush *a* through L_1 to *g*, also 110 volts from *a* to *g* through L_2; therefore, the neutral current will divide up equally between the two inductances, 10 amperes flowing through L_1 and 10 through L_2 around through half of the armature winding to brush *a*. This is just as it should be, since the currents are flowing through the inductances in opposite directions and are equal; the ampere-turns of one are in opposition to those of the other and no flux is caused to flow through the core, consequently no counter-voltage will be induced in L_1 and L_2.

Consider next the condition when the armature has made one-half revolution, as indicated in Fig. 4. This is identical to what we have in Fig. 2 except that L_1 is now connected to the negative point in the armature and L_2 is connected to the positive point. Consequently, with the load unbalanced 20 amperes, 15 will flow through L_1 to *c* and 5 amperes through L_2 to *d*. Now, it will be seen that the current has increased in L_1 from 5 amperes in Fig. 2 to 15 amperes in Fig. 4, also in L_2 the current has decreased from 15 in Fig. 2 to 5 amperes in Fig. 4. It is this variation in the current that generates the counter-voltage in the inductances as the armature revolves and takes the place of the alternating current that flows in the winding when the load is balanced, or when the machine is running without load.

It must be remembered that although the discussion gives the impression of a considerable lapse of time from one position to another, the transition in reality is very rapid. For example, such an armature might be revolving at a speed of 1500 r.p.m., which is equivalent to 25 revolutions per second, and it would therefore make one revolution in 1/25 of a second. Since all the changes in current described in the foregoing take place in one-half revolution, they occur in the space of one-fiftieth of a second.

We now see that through the use of inductances we are able to cause the current in the inductance between *g* and the positive terminal *a* to flow from *g* to *a*, which is impossible to do when resistances are used. Thus, in Fig. 5, which represents resistances instead of inductances, the current through R_1 would always have to be in the same direction as through R_2 for the position shown in the figure, the only difference being that the current through one would be greater than that through the other. Thus, in the position shown in Fig. 5 the current through R_2 would be greater than that through R_1. Of course, for the position shown in Fig. 6 the neutral current divides equally between R_1 and R_2 and flows in opposite directions as indicated. In the inductances Figs. 1 to 4, however, the current in L_1 is in the opposite direction from that in L_2 in all cases except those when the current in the neutral is very small. Such an arrangement of inductances therefore provides a convenient means of accomplishing the same results as are obtained with a balancer set, with an even greater degree of economy, and with the further advantage of dispensing with moving machinery.

In the explanation of the action of the inductance and how the current divides between them, many other elements that occur to affect the actual conditions have not been considered. This, however, has been done to simplify the reasoning as much as possible.

The problem of the preceding lesson concerned the voltages in a three-wire generator, such as that represented in Fig. 7. The voltage across *a b* was given as being 220 volts, and that across *c d* 190 volts. It was required to find the voltages across *a c* and *d b* and to determine whether the following points were positive or negative to each other, namely: *c* to *d*, *c* to *a*, *d* to *b*. It was also required to find the voltage across *a g* and *g b*, whether *g* is positive or negative with reference to *a* and *b*, and whether the position of the armature has any effect upon these latter voltage relations. The sum of the voltages across *a c* and *d b* must be equal to the difference between the voltage across *c d* and the 220 volts across brushes *a b*, and must therefore be $220 - 190 = 30$. Half of this exists across each of the sections *a c* and *d b*, so that the voltage across each is $\frac{1}{2} \times 30 = 15$ volts. The potentials of all parts of the armature winding above the center line *e f* are positive with regard to the potentials of all points below it. Consequently *c* is at a higher potential than *d* when in the position shown. As *c* approaches *a* its potential becomes greater until at *a* the two coincide; which means that in the position it occupies in the figure, *c* is at a lower potential than *a*. In a similar manner *d* must be at a higher potential than *b* since its potential gradually decreases as it approaches *b*. Since there is a constant voltage of 220 volts across *a b*, and since it has been established that the potential of *g* is always midway between that of *a* and *b*, it follows that ½ × 220, or 110 volts, must exist across *a g* and *g b*. Since *g* is between *a b* it must be negative with reference to the former and positive with reference to the latter. Since the voltage across *a b* is constant and *g* is always the mid-point, the position of the armature has no effect on the voltage relations between the points *a*, *g* and *b*.

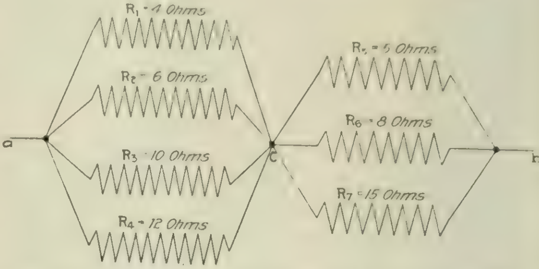
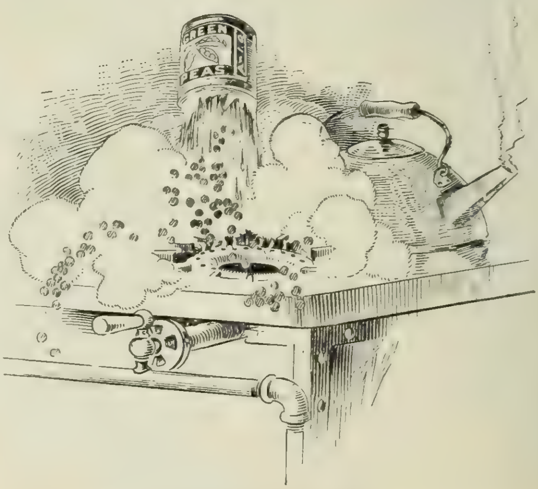


FIG. 8. RESISTANCES GROUPED PARALLEL-SERIES

Seven resistances, R_1, R_2, R_3, etc., are connected as indicated in Fig. 8. A voltage of 240 volts is applied across the points *a b*. What will be the value of the current flowing in each of the resistances?

There are various types of boilers and most of them will evaporate the same amount of water per pound of coal, if they are designed with the proper proportion of heating surfaces and grate area.



THE BURSTING POINT

EDITORIALS

Large Power Monopoly Economically Difficult

CHAIRMAN Alonzo R. Weed of the Massachusetts Gas and Electric Light Commission uttered a most significant truth at a recent hearing before the legislative committee on waterways and terminals at Boston, when he stated that power cannot be sold in large blocks except on a competitive basis. For this reason the man with a demand of, say, one hundred horsepower or more finds himself in most cases in a strong position to deal with an electric service company, when he comes to discuss power-contract terms. The fear is sometimes expressed that large power organizations can so completely dominate their territories that no one can withstand any attempts which may be made to "charge all the traffic will bear," as the saying goes. As regards the larger users, there is in most instances really little to fear in this respect. Rates to large users cannot attract the desired business unless they come fairly close to or below the cost of local production, including in that cost all the proper fixed charges and valuations. Even the small consumer is often in a position to bargain successfully, or if not, the possibilities in the way of isolated-plant service may reduce the regular rates for such supply sufficiently to warrant considering buying a part at least of the energy required. It is often forgotten that those who sell electricity really face competition in quite a number of forms and the lesson of this is that every operating engineer should undertake economic analyses of his plant's service and working without the least hesitation, requiring every outside offer of energy supply to clearly demonstrate its economic superiority to existing or possible results under skillful operating control.

Liberty has a message for all of us when she tells us that we must keep faith with those who sleep in Flanders Fields.

HOW CAN WE KEEP THE FAITH?

By over-subscribing the Victory Loan.

By doing justice to every worker and by meeting with patience and in a spirit of compromise the troublesome industrial problems ahead.

By rendering a fair day's work for a fair day's pay.

By insisting that the way of sound progress is by evolution, not revolution.

By making, each in his particular job, whatever sacrifices are necessary to bring about that reign of justice for which our sons and brothers suffered and laid down their lives.

They died that we might live in peace and happiness; shall we cast away their blood and scoff their death by strife and disorder and injustice?

Uniform Boiler Rules

A BOILER knows nothing about politics or geography. A given boiler operated with the same degree of care and intelligence is just as safe in Massachusetts as in Texas, and no safer.

On page 611 some of the principal differences between the Code of the Massachusetts Board of Boiler Rules and that of the American Society of Mechanical Engineers are set forth, as they apply to new boilers and new installations.

There may be some justification for differences in requirements as to existing installations. A state that has exercised supervision for a number of years may have gotten its boilers by gradual rejection and improvement into such a condition as to admit of the application of rules, which, if abruptly imposed in a state that has had no restrictions, would condemn thousands of boilers still reasonably safe. In this case the danger of the risk from explosion must be balanced against the loss by confiscation, the positively dangerous removed, and the process of gradual improvement instituted by insisting upon approved design and materials for new work with a gradual retirement of less reliable types.

But for new work the question is, or ought to be, one of simple engineering. If a longitudinal butt joint over twelve feet in length is dangerous in Massachusetts, it is just as dangerous in Ohio. If it is a source of real weakness, the A. S. M. E. code is at fault in not prohibiting its use. If it is not, the Massachusetts Board is unreasonable to exclude it. If the use of the fusible plug is so essential as to be required by law in Massachusetts, it ought to be required by the A. S. M. E. Code. All the differences to which the article in question calls attention are susceptible of conciliation by unbiased engineers when in possession of all the attainable information on the subject. The desirability of uniformity in regulations of this sort is too obvious to require argument. It is particularly desirable to the boiler manufacturer, who must otherwise keep the complicated assortment of stock and fittings necessary to meet a variety of requirements, run the risk of having his boiler rejected through the oversight of some idiosyncrasy of the law of the locality into which it is going—for cities as well as states have rules—and who cannot build boilers for stock, because each must be built to the code of the state or city where it is going. It is also desirable for the boiler inspector who could become thoroughly versed in one set of rules and keep up with its revisions, but who sees himself hopelessly swamped with a different set of rules for each state and a lot of others for different cities. And, too, it is desirable for the purchaser and user of boilers, for a uniform code would make standardization possible with all that it means in efficient and less expensive production, and a product that can be of only one kind.

Get together, gentlemen, and reconcile your differences! If they are of much of any moment, the superiority of one or the other treatment ought to be demonstrable. Those which are not of sufficient moment to be so determined could well be obliterated by mutual concessions. If the superiority of either is not sufficient to be demonstrable to a board or committee of unprejudiced experts, adopt either the one or the other and let us have a standard code and uniform practice.

The Clinker Grinder

WITH the continuing wider use of the large boiler and the stoker capable of high rates of combustion, mechanical means for the removal of ash from the boiler furnace became necessary to expedite operation. This is the prime function of the clinker grinder. As the road of refinements is the direction one must now take to better power-plant over-all efficiency, designers of modern clinker grinders strive to reduce to the lowest practicable minimum the combustible in the ash discharged from the furnace.

Elsewhere in this issue is an article treating of the development, present status and trend in the design and operation of these new appendages of the mechanical stoker. The author gives emphasis to his statement that the clinker grinder is intended for the exceptional rather than for the usual power plant. That is, for the plant burning large quantities of coal and operated by highly competent labor, the grinder is successful, but plants of usual capacity with the changing labor to which they are subjected are better off with the dump plate, which is now a part of the stoker, than with the clinker grinder of modern design.

Keeping Faith with the Fallen

HISTORY contains no finer example of altruism than that displayed by America as a nation during the recent war. With no aspirations for power, no secret yearnings for territory and no ancient grudges to settle, but with a firm and unalterable belief in those principles of freedom by which she herself had achieved greatness, she spent lavishly of her abundant wealth and freely of her blood that the world might enjoy with her the blessings of liberty.

So far as the United States is concerned, the war was fought and won by a united people. But for the unanimity of thought, purpose and action of a hundred million Americans there would have been no such splendid ending. Our soldiers battled so sturdily and successfully because they knew they were backed by the wealth and the will of the nation.

Those who fell—may we never grow indifferent to the magnitude of the debt we owe them!—yielded up for an ideal the one thing that was dearest to them. Faith in the righteousness of that ideal and in the resolve of the nation to bring it to realization sustained them.

Shall not that faith be kept? Shall it be said that we who remain and on whom they relied are recreant to that trust? Shall Liberty—depicted so graphically in the colored insert that accompanies this issue—call in vain to us to keep our promises to the heroes who lie beneath those rows of mute crosses?

The appeal comes in a score of ways. We can keep faith with them by supporting the institutions and principles for which they died—by scotching the snake of Bolshevism, by laboring to maintain industrial tranquillity, by meeting taxes cheerfully and philosophically, by Americanizing the immigrant and the ignorant, by fostering patriotism, by doing our own humble tasks as efficiently and capably as they did theirs.

We can keep faith with the dead by completing the work that their sacrifice made certain of success. But time and thought and money must still be spent to accomplish that end.

Subscriptions to the Victory Liberty Loan will show how well we keep our pledged word.

Some men seem to think that as soon as they obtain a position in a boiler room they are anchored there for life as firemen. Be this as it may, there is this to remember: The man who knows more about the fuel he burns and how and why it burns and puts his knowledge into practice, is the man who will be elevated to the higher and better paying boiler-room positions.

It may be difficult to draw the line between bituminous and sub-bituminous coals on the basis of moisture content, but the point may be settled by the behavior of the two fuels in weathering. Sub-bituminous varieties shrink, crack irregularly and partly disintegrate on exposure, while bituminous varieties shrink very little and do not disintegrate while drying.

Engineers hold various opinions regarding the construction of boiler settings. Some are in favor of designing them with an air space and others favor the solid wall construction. There is much to be said in favor of both types of settings, and it is probable that our readers may have interesting data on the subject.

The average man looks with favor on the job that is permanent. For that reason there should be a ready response to the appeal of the United States Shipping Board for first assistant engineers to serve on our merchant ships.

Universal raising of wages cannot permanently improve the condition of the workers if it is accompanied by smaller output and shorter hours. There must be greater efficiency and increased production.

When we see some fellow take the floor every fifteen minutes at an engineers' meeting, we are reminded that a babbling stream has to spread itself considerably to make up for its lack of depth.

After the Prohibition Amendment goes into effect, coroners' juries will have to account for disastrous boiler explosions on some other ground than that of intoxicated firemen.

Americanization is a filter that will rid us of such undesirable trash as hyphenated nationalities, Bolshevist tendencies and fanatical devotion to foreign interests.

From reports that come to us from time to time, it is evident that the safest place in the world is not to stand in front of a cylinder head.

The American army will need 50,000,000 gallons of fuel oil during 1919. Sure! we have oil to burn.

Correspondence

Difficulty Experienced in Getting a Generator up to Full Voltage

The armature of a 240-volt compound-wound direct-current generator was removed for rewinding, and upon being replaced the machine failed to generate. On the assumption that the residual magnetism had been lost, the shunt-field was flashed, in the usual way, from the bus with current from a 220-volt battery. This gave no result, the voltmeter remaining at zero when the machine was again started.

The shunt-field terminals were next connected with another machine generating about 210 volts. This brought the voltage up to about one-half normal value, but no further. Upon replacing the shunt-field connections the voltage again dropped to zero. Reversing the armature leads was next suggested, and this being done, the machine immediately picked up but in the wrong direction. The machine was stopped and the field again flashed from the battery and this ended the trouble.

Now I wonder if any of *Power's* readers will care to give the explanation for the benefit of those of us who are young in the profession—especially the reason why the machine generated the 120 volts when separately excited. ROBERT TOMLINSON.

Wheeling, W. Va.

Turbo-Blower Valve Control

After reading the article, "Placing Valves in Unsafe Positions," by V. R. Hughes, in the Feb. 25 issue of *Power*, it occurred to me that perhaps engineers would be interested in a description of two valves installed at the plant of the Mark Manufacturing Co., Indiana Harbor, Ind. These valves are on the delivery side of turbo-blowers that supply 34,000 to 55,000 cu.ft. of air per minute, at 14 lb. pressure, to the blast furnace. The air is taken in through two 72-inch intakes, the screened top of one of them being visible in the illustration. The 36-in. discharge lines lead from the blowers in the power house to the main discharge line outside. Here two 36-in. gate valves are located at the point where the 36-in. lines enter the 48-in. main discharge line.

From the illustration it will be seen that the valves are placed approximately 15 ft. above the ground, hence they would be very inaccessible to operate by hand. Besides, it would be inconvenient to operate the steam throttle on the turbo-blowers and valves simultaneously. At least two attendants would be required to close the throttle of one turbine and a gate valve at anywhere near the same time. To make the operation of the valves convenient and to guard against any serious irregularities of the air flow to the blast furnace, two Dean valve controls were installed in the two 36-in. discharge lines with the valve-control stations near the turbine throttles. With this equipment the engineer can start the turbine and then, by merely placing the handle of the valve-control station in the open position, open the corresponding discharge valve. This convenient and speedy control is especially desirable when changing from one turbine to another. The importance of being able to open and close these two valves rapidly will be appreciated when one remembers that blast furnaces are seldom shut down, but it is often necessary or desirable to shut down a turbo-blower.

The control is electrical in operation, using a fully inclosed motor connected to a system of combined worm and planetary gearing for the purpose of speed reduction to the valve stem. The gearing is inclosed in an oil-tight casing, and the limit mechanism is included in a space above the gearing. All cables from the motor to the limit switch are incased in steel conduit, and the unit is as impervious to moisture as it is possible to make it.

A 36-IN. GATE VALVE 15 FT. ABOVE THE FLOOR OPERATED FROM A CENTRAL STATION

The valve gate is driven directly into the seat, under power, and to the exact point of tight closing, after which the trip mechanism releases the motor and gears from the valve stem, thus preventing overtravel due to momentum of moving parts. In this way there is obviated any inability to securely seat the gates because of the motor circuit being interrupted before the limit of travel is reached and the gate being allowed to drift into its seat.

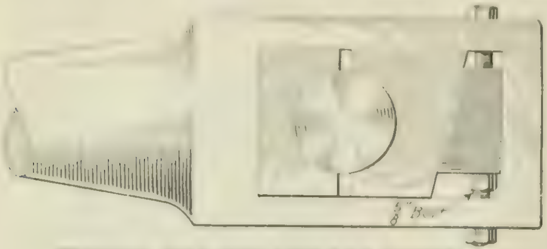
Control of the valves is secured by small control stations placed in cast-iron boxes suitable for attaching to wall or floor standards, and as many points of control as are desired, for one valve, may be obtained, at any varying distance from the valve. Each station is fitted with indicating lights showing the position of the gate.

Milwaukee, Wis. F. M. NOURSE.

Uses a Single Wedge Bolt

I have had trouble with wedge bolt breaking off below the wedge. As a remedy I removed the [illegible]-in. bolt and put in a [illegible]-in. bolt with a nut under the wedge, as shown in the illustration. This overcame my trouble and the bolt makes a better and safer job than the commonly used capscrew, and it does not loosen up as does the ordinary type of bolt. **M. J. Merrell.**

St. Louis, Mo.



THROUGH BOLT REPLACES TWO CAPSCREWS

Sources of Fuel Losses

Following is a copy of a letter I wrote some time ago to the engineers in charge of power plants under my supervision, pointing out wherein some of the losses are likely to occur:

It is demanded by the United States Fuel Administration and it is highly desirable that we spare no effort to cut down the consumption of fuel in our plants.

I would like to call your attention to some of the most common and most easily preventable sources of waste of fuel in stationary power plants. Probably the greatest loss of heat is up the smoke-stack. In the best-designed and most economically operated plants this loss will be about 15 per cent. of the total heat in the fuel and may be called unpreventable. In a poorly designed and carelessly operated plant it may easily be, and often is, 50 per cent.; that is, one-half of the heat in the fuel gone up the stack, from which we have derived absolutely nothing. What are the causes of this enormous loss and what can we do to prevent it?

Are you aware that a coating of soot 1/16 in. thick on the heating surface of your boilers will cut down the heat-transmitting efficiency 10 per cent. and as the thickness of soot increases, the loss increases a great deal faster?

In coal-burning plants the engineers should see that the boiler tubes are blown out thoroughly with dry, high-pressure steam or air at least two or three times each 24 hours. In oil-burning plants once a day will be sufficient if the fires are properly handled. You will find that it is quite an art to get just the right adjustment of steam and oil and air to the burners to obtain the best results. Return-tubular boilers should have a good scraper run through the tubes once a week.

Another common cause of heat loss is scale in the boilers; a coat of scale 1/16 in. thick will cause 10 per cent. of the heat in the fuel to go up the stack because it cannot get through the scale and into the water. And remember this: The only heat that makes steam is the heat that gets through the heating surface of the boilers and into the water.

So with a coat of soot 1/16 in. thick on one side and a coat of scale 1/16 in. thick on the other, 20 per cent. of the fuel value which should have gone into the water to make steam is going to waste up the stack. So be sure that your boilers are kept clean inside and out.

But the worst is yet to come. I believe that the cause of the greatest loss of heat up the stack is excess air. For complete combustion every pound of fuel requires just so much air. If we could admit just the right amount of air to the furnace there would be no loss from this source. This is impossible in practice, but by careful handling of the fires and intelligent manipulation of the dampers we can reduce the loss to a minimum.

Careless firing and poor adjustment of oil fires can easily result in a loss of 25 or 30 per cent. from this source. Add that to the 20 per cent. loss from soot and scale and you have a deplorable, though all too common, condition. Every pound of air over and above that required for complete combustion goes through without doing any good whatever; but when it comes out at the top of the stack it is mighty hot, and it took good coal or oil that cost good money to make it hot—all lost.

If there are any crevices in your boiler walls, excess air is going in there and taking good heat units up the stack. If your damper is wide open and your fire is too thin or has holes in it, large quantities of excess air are going through, robbing your boilers of the heat they should have. With oil fires, if you have your damper wide open with a light fire, great quantities of excess air will be going through your boilers.

It is up to us to get onto our jobs and watch these things closely and reduce the losses to a minimum and show that we are real engineers, not just starters and stoppers of engines and pumps, etc. I would like to see every engineer on the division take at least one good technical journal devoted exclusively to power-plant engineering. If closely studied, you will get the worth of the subscription price, and often a great deal more, from every issue.

May I ask the engineers in charge of plants to particularly interest themselves in the matters referred to in this letter to the end that we may have the most economically operated plants on the Santa Fé? If we do our part and show that we are worth it, it will be much easier to gain recognition of the fact that we are men in responsible positions in whose hands rests the saving or wasting of thousands of dollars—men in positions requiring skill and intelligence second to none.

Another matter: See that the water from the feed-water heaters goes to the boilers as hot as the pumps will handle it—the hotter we put it in the boilers the less fuel it will take to make steam of it. **W. G. Camp.**

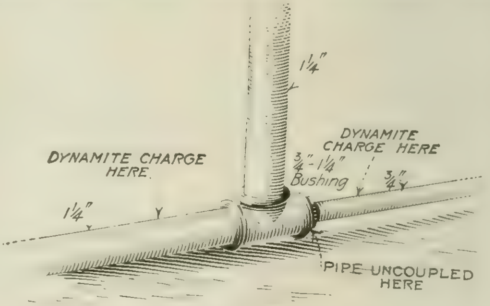
Winslow, Ariz.

Dynamite Uncoupled Pipe Line

Last winter I had a peculiar experience that I would like to have explained. I was having some water main laid, and as the ground was frozen, dynamite was used to loosen up the ground in order to get the work along faster. One stick of dynamite was used in each hole. The holes were about four feet apart, and the dynamite did the work fine. This work was done for a state institution where there are some old water pipes in the ground.

My peculiar experience was as follows: Two charges of dynamite were placed, as shown directly over a water line having a tee from which there is a service branch. This tee is 1¼ x 1¼ x 1¼ in., reduced with a bushing to ¾ in., and the exploding of two sticks of dynamite uncoupled the water pipe at the tee, although neither the threads on the ¾-in. bushing nor the threads on the ¾-in. nipple were damaged. Repairs were made with the same bushing and nipple, and the joint was made up tight under a water pressure of 30 pounds.

Chester, Ill. **E. S. Kimmel**

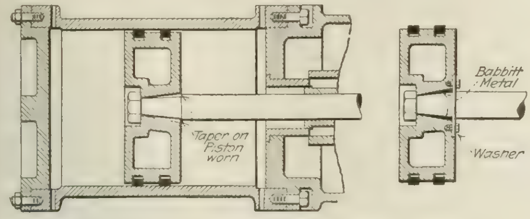


PIPING AND POINT OF PULLING APART

Loose Air-Pump Plunger Made Fast

Our air pump began pounding badly and the vacuum dropped back at intervals. Upon taking out the plunger, I found the piston loose on the rod, as shown in the illustration. It was made fast in the following way and it has given no trouble since. I made a washer out of ½-in. copper to fit the piston rod and fastened it to the piston with two ½-in. capscrews. I replaced the piston and rod in the pump, put in the piston packing to hold the piston central and bolted the follower plate down. Babbitt metal was then poured into the recess and peened down, and after fastening the washer securely, the job was done. JOHN T. LOCKETT.

Trenton, N. J.



PISTON AND ROD BEFORE AND AFTER REPAIRS

Furnace Heat-Resisting Material

The present-day operating engineer should receive the sympathy of everyone for having to listen to the line of talk advanced by salesmen who are presenting boiler-wall cements, high-temperature cements, firebrick that will not melt, heat-resisting paint, etc. It is remarkable how a salesman will talk about the heat-resisting qualities of his furnace cement or of the high temperature that his firebrick will withstand. He knows of the difficulty the engineer has in getting a reliable line on the performance of any refractory material used in the furnaces of the larger power plants, as the boiler load on the individual unit of a large plant is at best a variable quantity.

I have seen the very best of the so-called heat-resisting materials show signs of deterioration after a prolonged banking period, this trouble being evidently due to checks or cracks having developed during periods of comparatively low temperature. Some might think that in furnace practice we should take into consideration only the maximum temperature conditions, whereas the lower temperature conditions may prove to be more damaging.

The question then arises as to the best method of checking the performances of the furnace linings on trial. Some suggest a record of the steaming and banked hours, others the maximum rate of steaming as indicated by the record of a steam-flow meter; others take into consideration the apparent horsepower-hours developed; but with all these, one period of injudicious banking with the doors open with full or partial draft may do more damage than several days of maximum service.

I have found that a good way to get a line on the qualities of the various furnace cements, brick, etc., is not to build a complete furnace with any one product on trial, but to divide the surface, say using one make on one side wall and another make on the other; the bridge-wall can be divided also. If this is done, the work should be under the supervision of a representative of the manufacturers, and instead of being placed upon trial the material should be paid for so that if a failure occurs, as it generally does, the engineer will not be bothered by requests for a repeat trial. Work installed in this way is subjected to like changes in furnace conditions, and after the test there is no doubt as to which is the best material. JOHN F. HURST.

Louisville, Ky.

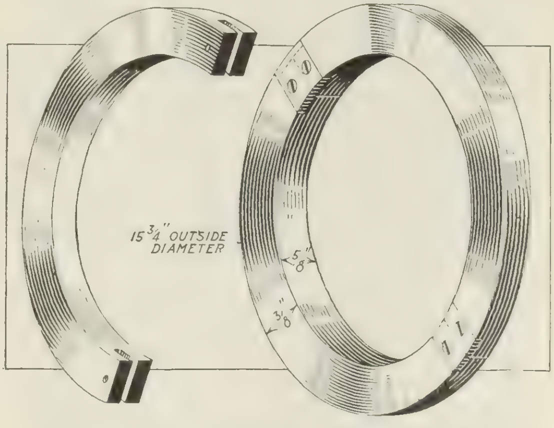
Repairing Oil Rings of Gas Engine

On examining the outboard bearing of a 650-hp. vertical gas engine that had been giving considerable trouble, it was found that the oil ring was broken in two places, leaving it practically in halves. To make a new ring and raise the shaft to get the bearing out to put the new ring in place would take approximately four days.

The ring was 15¾ in. outside diameter, ⅜ in. thick and ⅝ in. wide. The broken pieces were removed and a piece cut out of one side of the ring at the break to a depth of 5/16 in. and about ½ in. long on each side of the break. Next a ¼-in. hole was drilled and tapped, one hole on each side of the break. Pieces were then fitted in the offsets cut in the ring and drilled for ¼-in. screws and in line with the tapped holes in the ring. The lobs of the plates were countersunk on one side to allow the screw heads to come flush with the metal. The plates were next secured to the ring by screws. All were filed to the same radius as the ring, both inside and outside. The ring was then put in place and has been running and doing good work for the last three years. It is shown at the right of the illustration.

Another good way to repair broken oil rings of small size is shown at the left of the illustration. For rings that have not enough stock to cut out and set in a piece, as in the first instance, a good way is to split the ring in the center of the width, as shown. This is done on each broken end. The corresponding ends are then put together and pieces of tin inserted in the slots and held in place by drilling through the side of the ring and the tin keepers, using a small piece of copper as a rivet to hold the tin and ring in place. If tin is not at hand, a piece of a saw blade can be used after drawing the temper. R. G. CURREN, JR

Kittanning, Penn.



TWO METHODS OF REPAIRING THE OILING RINGS OF A GAS ENGINE

Difference in Water Level in Boilers

I read with interest an article by F. R. McLean in the Feb. 11 issue of *Power*, page 201, relating to "Differences in Water Levels in Boilers." My experiences with steam boilers, especially in connection with water levels, may be of some value, and are as follows:

Upon installing feed-water regulators on three-drum horizontal-water-tube boilers, I have noticed effects similar to those described by Mr. McLean. However, I have also noticed this in boilers set singly, as well as in batteries. I have observed this effect on hand-fired as well as stoker-fired boilers, so it can hardly be caused altogether by the condition of the fire. It is sometimes difficult to observe this result on hand-fired boilers, because firing has its effect on the water level also.

I believe this difference in water level is due to the feed or method of feeding as much as to the fire. I have found that low water frequently occurs in the drum nearest to the main feed and the highest water in the drum farthest from the main feed. With some boilers it is customary to run the feed line over the top of the drum heads, dropping down to each drum. When the feed is throttled so that the flow through the pipe is gradual, it is probable that most of the water drops down the first pipe it comes to, hence introducing comparatively cold water into the drum nearest to the main feed. This will cause a circulation through the boiler toward the farthest drum and because the coldest water is in the near drum, most of the steam will be formed in the farthest drum or in tubes under it. This theory is borne out by Mr. McLean.

He also says: "When the individual feed line to one drum was found obstructed, that section would show high concentration of salts, mud and scale. By installation of orifices of slightly different sizes in the individual feed lines, a reasonably uniform concentration of deposits was obtained in all three drums."

Usually, in a double setting the feed comes from both sides, so this would cause the highest level in the center of the setting. I believe a better distribution of water would be obtained by running the main supply pipe under the drums and coming up to them. This probably would interfere with the doors unless the connections were made short or curved. Perhaps it would be better if the boiler manufacturers or erecting engineers would increase the size of the feed line progressively across the front of the boiler, instead of decreasing it to eliminate as much friction as possible. It is doubtful, though, if this alone would prevent most of the water going down the first pipe at low loads. There are so many factors involved that a single orifice under constant pressure can hardly be expected to take care of all conditions.

I have also noticed the difference in pressure between drums even when apparently plentifully supplied with equalizers. I believe it is possible to have the same level shown by a column in one end of a drain as the other, provided the baffles inside the drum are placed so as to insure this. However, there is no doubt that with steam rising in the front header and not in the back header, the specific gravity in the front of the boiler is less than in the back. Hence, there must be a difference in level. This was shown by Paul Bancel's interesting experiments on a small boiler, as described in the Transactions of the A. S. M. E. It has also been borne out by innumerable other experimenters and observers.

Erie, Penn. V. V. VEENSCHOTEN.

Overheating Hot Water Wasteful

It would seem at first glance that the statement in the letter by W. T. Meinzer, on page 256 of the Feb. 18 issue, on "Overheating Hot Water Wasteful" is true, but conditions often change things.

For instance, when it comes to dollars and cents, it does not make much difference whether you use 1000 lb. of water at 180 deg. F. or whether you use 1800 lb. at 100 deg. F. I had an experience along this line several years ago in a large modern factory building designed to house 1000 employees. Every floor was equipped with modern lavatories, and the help were supposed to come to work and go home clean. The tank for heating the water was suspended high enough above the boilers to return the condensate from the coils in the tank to the boilers by gravity.

The temperature was regulated automatically by a thermostatic control, and everything apparently was according to the best-known methods. By the way, the exhaust steam was all used in the process, so it was useless to think of exhaust for the hot-water service. More or less hot water was used during the day, but the genuine pulls came at 11: 45 a.m. and 4: 45 p.m. Different ones were detailed to fill the sinks with water for each floor, and they turned the hot-water faucets wide open in about twenty or thirty lavatories numbering from six to ten sinks each.

Now they wanted the water about 100 deg. F., and so it had been carried at 110 on the tank, but they did not get it half fast enough. The plant was designed to carry the hot water at 180 deg. F. originally, but to try and save a little fuel the engineer had cut the temperature. As the returns from the coil in the tank were well covered and came back properly, the saving was very little but the trouble it caused was considerable.

If a system is designed to furnish a certain amount of hot water per hour at a higher temperature, it will do it on smaller pipe than a lot of water at a lower temperature. This was the trouble in the case cited. It was figured that the hot and the cold water faucets would be opened together, so that but half the hot water would be used, thus supplying all faucets at practically the same time.

I put the temperature back where it was intended to be, and a few more degrees for good measure. As near as we could weigh the coal, we could not detect any difference in the amount burned, but the superintendent, the manager and even the president of the company visited the power plant and said the service was the best it had been for two years.

We also lowered the ball floats in the toilets about one inch and saved an amount of water almost unbelievable. I do not want to go on record as saying that coal cannot be saved by lowering the temperature—it sounds very good—but I am citing this case as an example.

Some years after this experience I was asked by an engineer in an apartment house how to get more hot water through the pipes. I told him to heat it more and send it up hotter and perhaps the tenants would use more cold with it and less hot water. He heated the water automatically with the exhaust from a lighting engine and an elevator pump. I saw him a few weeks after and he said everything was working satisfactorily.

Auburn, Mass. C. W. PETERS.

Inquiries of General Interest

Reconnecting Induction Motors—Can a 60-cycle, 550-volt, three-phase induction motor be reconnected to operate on 440 volts two-phase? The machine now runs 480 r.p.m. at full load, has 168 coils in the winding, connected in single-circuit star. N. W. W.

The winding as now connected has 14 poles grouped four coils per pole per phase. By regrouping the winding for two-phase 6 coils per pole per phase, connected in series, the motor will operate on a 440-volt two-phase circuit. The two-phase voltage is 80 per cent. of the three-phase volts, and the winding as reconnected will operate on 81 per cent. of the three-phase volts, or 550 × 0.81 = 445.5 volts, consequently this will be satisfactory for 440 volts.

Calculating Power Factor—Our alternators are three-phase, 600-volt, 1500-kw. machines. If the wattmeter indicates 1300 kw. and the ammeters each read 2000 amperes, what would the power factor be? Is low power factor the cause of poor voltage regulation? E. Mc.

The kilovolt-amperes of a balanced three-phase circuit is kv.-a. = $\frac{EI \times 1.732}{1000}$, where E is the volts between terminals and I the current in amperes per terminal. Then in this problem kv.-a. = $\frac{600 \times 2000 \times 1.732}{1000} = 2018.4$. The power factor (p. f.) equals kilowatts (kw.) divided by the kilovolt-amperes (kv.-a.), or p. f. = kw. ÷ kv.-a. = 1300 ÷ 2078.4 = 0.62. Low power factor is one of the causes of poor voltage regulation. A power factor of 0.62 is considerably lower than would be considered good operating practice.

Increase of Power for Pumping Additional Delivery—If a pump raises 150 gal. of water per minute to a height of 25 ft., how much more power will be required if the pressure is increased sufficiently to elevate one-sixth of the water 12 ft. higher, or a total height of 37 ft.? P. F. K.

To raise the water to a height of 25 ft. would require the pump to work against a head of 25 ft. plus the head lost in overcoming pipe friction, and to raise any portion of the pump discharge to a height of 37 ft. would require the pump to discharge the whole delivery, or 150 × 1⅙ = 175 gal. per min., against a head of 37 ft. plus the head lost in pipe friction; and the original 150 gal. per minute would be discharged under a head of 12 ft. plus the additional head lost in pipe friction due to delivery of the one-sixth more water. Neglecting pipe friction, an increase of head from 25 to 37 ft. would require $\frac{37}{25}$ as much power and for increasing the pump discharge from 150 to 175 gal. per min. would require $\frac{175}{150}$ as much power, so that $\frac{37}{25} \times \frac{175}{150} = 1.726$ times as much, or 72.6 per cent. more power would be required.

Temperatures Within Boiler Water Column—In a water column of a boiler carrying steam at a gage pressure of 125 lb. per sq.in., what would be the temperature of steam in the water column ¾ in. above the level of the water and the temperature of the water ¾ in. below the surface covered by steam? J. V. H.

For all practical purposes the temperature ¾ in. above or below the surface of the water would be the same as that of dry saturated steam at a pressure of 125-lb. gage; namely, 353 deg. F. Radiation of heat usually is taking place from the steam connection of water columns of boilers while under steam pressure, and consequently there is slightly less pressure and lower temperature of the steam at or near the water level in the column and gage-glass than the temperature of steam and of water in the boiler; but ordinarily, the difference would be imperceptible. However, the column might be so exposed to cold that the water any distance below the surface would be considerably lower in temperature than the temperature of the steam, depending on circulation and insulation. The temperatures are controlled by the same principles as those which determine temperatures within pipes and radiators of a two-pipe gravity-return steam-heating system. The steam connection of the water column corresponds to the supply line, the steam space corresponds to the radiators and portions of the system not flooded with water, and the water connection of the water column corresponds to the flooded return pipes of the heating system, which may become sufficiently chilled by the surrounding atmosphere for the water within them to become frozen from the radiators clear back to the boiler.

Determining Size of Motor Required for Fan Blower—We have a 42-in. diameter fan blower which, when driven at 750 r.p.m., will handle 20 to 25 tons of ensilage per hour and elevate it 30 ft. According to the manufacturers, the blower doing that work required four to six horsepower. We have increased the speed to 1200 r.p.m. and handle the same quantity of material per hour elevated 62 ft. The blower is driven by an engine and we wish to change to motor drive. What size of motor should be provided? B. H.

The data and conditions are not sufficiently complete and exact for deciding the probable characteristics of operation of the blower. The best method of determining the size of motor to be used would be to ascertain the power required by indicating the engine while carrying a constant load with and without the blower. The difference will be the power required for the blower. Another method is to measure the power with some form of transmitting dynamometer. Other ways of testing would be by substitution of an ascertainable brake load. If the power taken by the blower is more than about one-fourth the capacity of the engine, run the blower doing regular work, using the regular throttle valve for starting and stopping the engine, and with a stop-valve between the regular engine throttle and the boiler, but with the regular throttle wide open, throttle down the supply of steam to a point where the blower doing regular work will be driven only just up to proper speed. Then, without changing the position of the stop-valve, stop the engine by closing the regular throttle valve, remove the belt from the blower and apply a prony brake to a pulley on the blower countershaft and determine the greatest brake power that can be developed by the engine with full throttle, the same opening of the stop valve and the same steam pressure as before on the boiler side of the stop-valve.

If it is impracticable to thus employ a stop valve for gaging the flow of steam under identical conditions, so as to obtain the same development of power when the engine carries the substituted brake load, another method is to drive the blower countershaft with a slack belt brought to the necessary tension with a weighted tightener-idler pulley by means of which the tension of the countershaft driving belt may be made only just sufficient for driving the blower to the proper speed. It then can be ascertained how much prony brake load can be laid on the countershaft as a substitute for the blower load under the same conditions of belt tension.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Synchronous-Motor Drive for Ice Machines

THE manufacture of ice and refrigeration is increasing rapidly in this country at the present time, and the cost of power is a very large item in the value of finished product. In fact, there is more primary power used per $1000 of product in the manufacture of ice than in any other industry. Census reports of 1914 (in ice-manufacturing plants) showed 7.64 of installed primary horsepower to every $1000 of annual product.

Many ammonia compressors ranging from 100 hp. up are now being equipped with direct-connected synchronous motors. A synchronous motor is the only type that is practical to use at the slow speeds required. What are called low motor speeds (say around 200 r.p.m.) are high compressor speeds; in fact, it is only within the last few years that it has been made possible to build compressors with speeds of 200 r.p.m. or higher. This was mostly due to the development of the high-speed plate valve with low lift. A better system of lubrication for reciprocating parts has also helped. Actual piston speed has not been materially increased because the length of stroke is correspondingly reduced on high-speed compressors. Large steam-driven compressors were operated at varying speeds according to the output of ice required. Sometimes the speed was as slow as 20 r.p.m.—sometimes went up to 80 or 90 r.p.m. or higher.

VARIABLE SPEED OF ICE MACHINES NO LONGER NECESSARY

Most engineers admit that it is no longer necessary to provide for variable speed of the ice machines in order to take care of fluctuating demands for ice. Plants are planned with a number of constant-speed compressor units which can be operated singly or in parallel so that any desired ice-making capacity can be secured. For instance, a typical plant with 400 tons daily capacity (ice) might have four compressors—one rated at 150 tons, two at 100 tons each and one at 50 tons. With such an arrangement the daily output could be maintained at any desired amount in tons—50, 100, 150, 200, 250, 300, 350 or 400. The machines would always be running at constant speed and practically full load, at their highest efficiency.

An ammonia compressor is a reciprocating machine with heavy moving parts and has an oscillating torque curve very similar to that of a steam engine. The load increases toward the end of the stroke and this recurs at regular intervals, so that unless something is done to damp out this peak it may start the motor to oscillating.

Sufficient flywheel effect should be supplied to reduce the angular displacement of the poles at these periodic intervals to about three electrical degrees. In order to give a clear idea of what this means, consider the displacement reduced to inches. The distance from the center of one pole to the center of the adjoining pole on a rotor is 180 electrical degrees. On a 36-pole (200-r.p.m.) motor this distance might be, say, 5.5 in.—three electrical degrees would be less than 0.1 of an inch. The rotor could slide back only this small space at the end of each stroke—and of course it would have to regain this during the return stroke so as to be ready to slide again when the piston approached the opposite end of the cylinder (speaking now of a double-acting compressor).

The flywheel, as you know, can act only during a change of speed—and the change of speed allowed in this case is limited by the motor characteristic to a very infinitesmal amount—the time it would take the rotor to drop back 0.1 of an inch.

We, as motor builders, are not prepared to say what is the proper flywheel effect that should be supplied to a certain compressor; that, we believe, is the function of the engineer who designs the machine. We know that it is advisable to keep a difference of at least 20 per cent. between the natural frequency and the forced frequency (r.p.m.).

When compressors are diven by direct-connected steam engines there is a combination of two oscillating torques—that of the reciprocating engine and that of the reciprocating compressor. In some cases the torque of the engine piston is diminishing at the time when the torque required by the compressor piston is increasing. Under such circumstances the flywheel must be designed to take care of smoothing out the unevenness, both on the engine end and the compressor end.

But with the synchronous motor conditions are entirely different. The motor delivers to the compressor a smooth, even flow of power. It has no low point or dead-center such as in the case of the engine. Consequently, it does not require the flywheel to assist it to anything like the same extent. As a matter of fact the line itself acts as a flywheel to carry the motor over sudden loads. It is desirable to hold down these jerks of power on the line, and of course the flywheel does help materially in smoothing them down. It should be remembered that the central station's attitude today is somewhat different from that of a few years ago. Systems are now so large and the diversity factor of various loads is such that they can stand a great deal more from a motor than was formerly allowed. For instance, a large power customer with a number of big motors would probably have no difficulty in starting any one of his motors singly even if they should take quite a large kv.-a. from the line.

ADVANTAGES OF DIRECT-CONNECTED MOTOR

It seems hardly necessary among ice and refrigerating men to spend much time outlining the advantages of having the motor direct-connected to the compressor. All the auxiliary equipment of belts, ropes, pulleys, etc., is eliminated. Floor space is valuable in artificial ice plants, which are generally in downtown sections of large cities where ground is very expensive. Nearly all the space formerly occupied by the driving engine can be gained. This means a saving of 30 to 40 per cent. in floor space.

Of course the greatest argument in favor of direct connection is the saving in power by the cutting out of all transmission losses. These power losses in an average plant are seldom less than 10 per cent. and may run as high as twice this amount. The tremendous saving in yearly power bills is what interests all engineers. The efficiencies on unity-power-factor synchronous motors are remarkably high, and this is the compelling reason for the refrigerating engineer. For instance, a certain 560-hp. 225-r.p.m. motor driving a compressor tested as follows: Efficiency at one-half load, 95.6 per cent.; three-fourths load, 98 per cent.; full load, 96 per cent.; and 125 per cent. full load, 95.4 per cent.

ECONOMY OF DIRECT-CONNECTED SYNCHRONOUS MOTOR

It is believed that it can be definitely proved that the most economical drive for an ice machine is a direct-connected synchronous motor. The discussion has been limited to direct-connected units only. There are many belted synchronous motors driving ammonia compressors that also operate at high efficiency and unity power factor. It is sometimes necessary, from the nature of the conditions, to use a belted motor, as when a very slow-speed old-style compressor is to be driven. Compressor speeds around 200 r.p.m. have been spoken of. It is possible that in the future synchronous motors may be direct-connected at speeds considerably lower than this. It is known to be feasible to design and build a motor with as low as one kilowatt capacity per pole. If it should be found advisable to use slower speeds than those mentioned, motors could be designed for direct connection.

In the case of an isolated plant generating its own alternating current, the use of an overexcited synchronous motor at a leading power factor is often desirable. Such a motor, if properly designed, may operate at a power factor, say, 80 per cent. leading while at the same time carrying 0.75 of its rated mechanical load in horsepower. The motor under this condition may exert nearly the maximum of

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*Abstract from a paper read by J. R. Watson, Mar. 19, 1919, before the Engineers' Society, Milwaukee, Wis., under the auspices of the Milwaukee Section of the American Society of Refrigerating Engineers.

corrective effort on the system's power factor. (The condition of the system as to kv.-a. capacity and power factor must be taken into consideration.)

This matter of power-factor improvement cannot be met in the future as it has been in the past, simply by the central station installing large synchronous condensers. It will become more and more desirable to have a connected load of many fair-sized synchronous motors scattered over the system. This is much better from the standpoints of voltage regulation, transmission efficiency, etc., than the old method of combining all the power-factor correction for the circuit in one or more synchronous condensers.

The result will be that central stations will encourage the use of synchronous motors more and more on their lines. This tendency is already apparent in many sections of the country, especially where heavy individual users of power are scattered over the system.

Growth in the Electric Light and Power Industry

According to a report about to be issued by Director Rogers, of the Bureau of Census, Department of Commerce, the electric light and power stations in the United States during 1917 generated more than twenty-five billion kilowatt-hours of electric energy, producing an income of more than a half billion dollars, and gave employment to more than 100,000 persons, whose salaries and wages aggregated nearly $100,000,000. The output in 1917 was more than double that for 1912 and more than quadruple the output for 1907.

ELECTRIC LIGHT AND POWER STATIONS, 1917, UNITED STATES

	1917	1912	1907	Per Cent. of Increase* 1907 to 1917	Per Cent. of Increase* 1912 to 1917	Per Cent. of Increase* 1907 to 1912
Number of establishments	6,541	5,221	4,714	38.8	25.3	10.8
Commercial	4,224	3,659	3,462	22.0	15.4	5.7
Municipal	2,317	1,562	1,252	85.1	48.3	24.8
Income	$526,886,408	$302,273,398	$175,642,338	200.0	74.3	72.1
Electric service	$502,100,346	$287,138,657	$169,614,691	196.0	74.9	69.3
All other	$24,786,062	$15,134,741	$6,027,647	311.2	63.8	151.1
Total expenses, including salaries and wages	$427,136,049	$234,577,277	$134,196,911	218.3	82.1	74.8
Number of persons employed	105,546	79,335	47,632	121.6	33.0	66.6
Salaries and wages	$95,239,954	$61,161,941	$35,420,324	168.9	55.7	72.7
Total horsepower	12,857,998	7,530,044	4,098,188	213.7	70.8	83.7
Steam engines:						
Number	7,464	7,847	8,054	—7.3	—4.9	—2.6
Horsepower	8,389,389	4,949,778	2,693,273	211.5	69.5	83.8
Internal-combustion engines:						
Number	2,946	1,116	463	536.3	164.0	141.0
Horsepower	217,186	111,035	55,828	289.0	95.6	98.9
Waterwheels:						
Number	3,357	2,939	2,481	35.3	14.2	18.5
Horsepower	4,251,423	2,469,231	1,349,087	215.1	72.2	83.0
Kilowatt capacity of dynamos	9,001,872	5,165,439	2,709,225	232.2	74.3	90.7
Output of stations, kilowatt-hours	25,438,611,417	11,569,109,885	5,862,276,737	333.9	119.9	97.3
Stationary motors served:						
Number	554,917	435,473	167,184	231.9	27.4	160.5
Horsepower	9,216,323	4,130,619	1,649,026	458.9	123.1	150.5
Number of street lamps:						
Arc	256,838	348,643	†	..	—26.3	
Incandescent, etc	1,389,382	681,957	†		103.7	

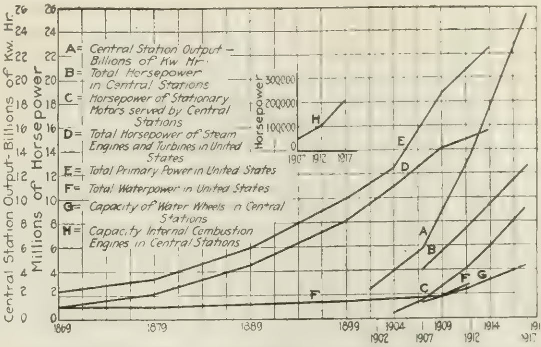
* A minus sign (—) denotes decrease. † Not available.

This report, which was prepared under the supervision of Eugene F. Hartley, chief statistician for manufactures, covers both commercial and municipal plants, but does not cover electric plants operated by factories, hotels, etc., which generate current for their own consumption, plants operated by the Federal Government and state institutions, nor plants that were idle or in course of construction at the time of the investigation.

The figures show great strides in the industry during both of the five-year periods 1907-12 and 1912-17. The output of electric energy by the light and power stations increased at a considerably greater rate, and their expenses at a slightly greater rate, than their incomes; the rate of increase in the number of persons employed was much smaller, particularly during the later five-year period, than that in the amount of business done.

The total number of establishments increased from 5221 in 1912 to 6541 in 1917, the latter comprising 4224 commercial and 2317 municipal establishments. The increase indicated by these figures is somewhat misleading, since 2296 new establishments came into existence between 1912 and 1917, but as a result of combinations in the commercial systems and various other changes the net increase was only 1320, comprising 565 commercial and 755 municipal stations.

The total income of the stations in 1917, of which 95.3 per cent. represented electric service, amounted to $526,886,408, an increase of 74.3 per cent. as compared with 1912 and of 200 per cent. as compared with 1907. The total expenses were $427,136,049, or 82.1 per cent. more than in 1912 and 218.3 per cent. more than in 1907. The employees of the light and power stations numbered 105,546, an increase of 33 per cent. over 1912 and of 121.6 per cent. over 1907; and their salaries and wages aggregated $95,239,954, an increase of 55.7 per cent. as compared with 1912 and of 168.9 per cent. over 1907.



TREND OF POWER INDUSTRY IN THE UNITED STATES COMPILED FROM SEVERAL SOURCES

Fuel-Oil Prices to Shipping Board

The Director of Operations has awarded the following fuel-oil bid for United States Shipping Board vessels to be taken during the next twelve months. Quantity not fixed. All U. S. S. B. vessels loading at Port Arthur, Texas.

Delivery and Grade	Price per Bbl., 42 U. S. Gal.
No. 1 "B"	$0.84
No. 1 "C"	.74
No. 2 "B"	.84
No. 2 "C"	.74
	Plus 10c. per bbl. for lighterage, subject to minimum charge of $500
No. 3 "B"	$0.84
No. 3 "C"	.74
	Plus rail freight, refinery to wharf, f.o.b. tank cars

In a series of tests made to determine the light-transmitting properties of fresh water, it was found that, taking the illuminant at the surface of the water as 1, approximately 0.75 part would be transmitting through 1 ft. of water, at 5 ft. 0.20 part, and at 100 ft. only about 0.000,000,000,000,01 part of the total illuminant at the surface reaches this depth.

Electrical and Illuminating Engineers Hold Joint Meeting

On Friday evening, Apr. 11, 1919, the American Institute of Electrical Engineers held its 349th regular meeting. This meeting was held under the auspices of the Lighting and Illumination Committee of the A. I. E. E. and was a joint meeting with the Illuminating Engineering Society. One paper, "Present Status of Industrial Lighting Codes," presented by G. H. Stickney, gave an outline of the necessity and scope of industrial lighting codes together with an analysis of the specifications of such items as the intensity, limits of glare and distribution of illumination as related to modern industrial lighting. The paper discussed the industrial lighting codes based on the Illuminating Engineering Society's code, now enforced in Pennsylvania, New Jersey, New York and Wisconsin. It also referred to the coöperative work between the Departments of Labor, Industrial Commissions and other agencies charged with the enactment and enforcement of regulations regarding industrial lighting. .

Comfort A. Adams, president of the American Institute of Electrical Engineers, presided. In his opening remarks he referred to the many difficulties in establishing a lighting code satisfactory to all parties interested and said that those who have done the work on the code, referring to that of the Illuminating Engineering Society, should get considerable comfort out of their work, for they have performed a real public service.

Repairing Boilers by the Electric or Oxyacetylene Process

The British Board of Trade has published for official use an instruction to surveyors of vessels on the subject of making repairs to the boilers of passenger steamers by the electric or oxyacetylene process, as follows:

The repairing of the boilers of passenger steamers by the electric and oxyacetylene processes has been tentatively in operation for a considerable period and, in view of the experience gained, the surveyors are informed that, provided the work is carried out to their satisfaction by experienced workmen, these processes may be employed, within limits, for repairing cracks in furnaces, combustion chambers and end plates of boilers, and in the same parts for reinforcing the landing edges of leaky riveted seams which have become reduced by repeated chipping and calking.

In some old furnaces which have been repaired by these processes it has been found that, after a few months' working, cracks have again developed at parts adjacent to those welded, probably owing to the original material of the furnace having become fatigued and worn out by long and severe usage. In dealing with old furnaces, therefore, this fact should be taken into consideration.

It has also been brought to the notice of the board of trade that a shell plate of a cylindrical marine boiler cracked recently through a solid part where some surface welding had been done by the electric process two years ago. The welding had extended for a length of about 12 in. along the outside calking edge of one of the middle circumferential seams at the bottom of the boiler, the leaky edge of the seam and the adjoining shell plate having been covered (soldered) by metal deposited by this process in the usual way. The shell plate was 1$\frac{5}{32}$ in. thick and the crack, which followed the line of surface welding, extended in a circumferential direction for a distance of 2 ft. 9 in., the welded part being situated midway along the crack.

For the present it is not proposed to prohibit, within limits, the reinforcement of the circumferential seams of boiler shells if the end plates are well stayed, but no welding should be done to these parts by any process which may cause local heating over an appreciable area of the plate, such as the oxyacetylene, oxyhydrogen, or other similar methods. In no circumstance should any part of a boiler of a passenger vessel be welded if wholly in tension under working conditions, such as a stay or the shell plate at a longitudinal seam, the failure of which by cracking at the welded part may lead to disastrous results.

In any case in which the proposed repairs to the boilers of passenger vessels by either of these processes are of an uncommon or unusually extensive character, the particulars should be submitted for the board's consideration and approval.

After repairs by welding have been completed, the parts at or adjacent to the welds should in all cases be well hammer tested; and, and unless the welding is of a trifling character, a hydraulic test of not less than one and a half times the working pressure should be applied to the boiler after the hammer testing has been effected.

Brains Versus Brawn

Observing that a young workman on an excavation job was accomplishing about twice as much work as any one of his fellows, the superintendent kept a close eye on him. When a problem was presented of lifting a heavy piece of steel from a point one hundred feet beyond the reach of the derrick boom, every workman was called to the task. After a few minutes of fruitless effort the zealous one suggested that the boom be lowered to the ground. He then led the cable to the steel beam and fastened it. The engine started, easily drawing the beam along until it reached the boom-end. The boom was then raised in the usual way and the big steel piece which had defied the concerted strength of twenty husky workmen was quickly lifted and deposited on a waiting truck.

Noting the quick-witted young man's action, the "super" inquired of him where he had picked up his engineering ability.

"In the army," replied the worker. "This is nothing to what we engineers did in France."

"Well, my boy," said the superintendent, "tomorrow you go on our payroll as a construction foreman."—*The Wall Street Journal Straws.*

First Assistant Engineers Wanted

The United States Shipping Board wants first assistant engineers. There is a present shortage in this grade in the merchant marine and highly paid positions are ready for men who can fill them. Qualified applicants are directed to report to the Sea Service Bureau at any large American port.

Owing to the great demand for officers in the grades mentioned, the Shipping Board has ordered its officers' training schools to accept for intensive training any merchant marine officer who wishes to brush up in preparation for examinations for a raise in grade, and second mates and second assistants are urged to take these courses in order to shorten the time in which they may obtain first mates' or first assistant engineers' licenses.

Schools for engineers are now opening new classes for a month's training. The following technical colleges are giving such courses: Massachusetts Institute of Technology, Cambridge, Mass.; Case School of Applied Science, Cleveland; Armour Institute, Chicago; Tulane University, New Orleans; University of California, Berkeley; University of Washington, Seattle.

It has been found that by keeping hot water under pressure in contact with a large surface of iron for a sufficient length of time, it is possible to remove and fix the oxygen contained in the water and thus render the latter practically noncorrosive. The successful application to practical uses of this method, devised by F. N. Speller, metallurgical engine of the National Tube Co., has been demonstrated in the heating system at the Irene Kaufmann Settlement in Pittsburgh, where test lengths of uncoated wrought-iron and steel pipe have been reëxamined after two years' service and found to be practically uncorroded. Duplicate pipe in the same system, but unprotected in this way, showed considerable corrosion.

The *Electrical Engineer*, London, mentions a novel method of cleaning condenser tubes by blowing through them water with sand in suspension. Originally, an air pistol was used to project the water, but subsequently sand was introduced by means of the circulating water, about 1½ cu.yd. being added to the water daily. After three weeks of this treatment, it is said the condition of the condenser was much improved. The size of the condenser is not stated.

Engineering Affairs

The Indiana State Association of the N. A. S. E. will hold its convention at Terre Haute, Ind., on June 26, 27 and 28.

The Master Boiler Makers' Association will hold its annual convention at the Hotel Sherman, Chicago, May 26 to 29.

The Association of Iron and Steel Electrical Engineers, Pittsburgh Section, will hold a meeting on Apr. 26, at Chatham Hotel. A paper entitled "Electricity Afloat; Steel Mill Practice Applied in the Navy" will be read by Lieut. A. M. McCutcheon, U. S. N.

The Association of Iron and Steel Electrical Engineers, Chicago Section, will hold a meeting on Apr. 26, at the Great Northern Hotel. A joint paper, "Safety in Steel Mills," will be read by C. M. Brading, superintendent of safety, and F. A. Wiley, electrical superintendent, Wisconsin Steel Co., South Chicago, Ill.

The New York Chapter of the American Association of Engineers will meet at 8 p. m., Wednesday, Apr. 23, in the United Engineering Societies Building, 29 West 39th St. The speaker will be Dr. George W. Kirchwey, Director of the United States Employment Service, and his subject will be "Solving the Unemployment Problem."

The American Society of Heating and Ventilating Engineers, at a meeting of the Council on Apr. 7, decided to hold its semi-annual meeting at Pittsburgh, Penn., on June 10, 11 and 12. This meeting is to be held jointly with the annual convention of the National District Heating Association. Announcement of the headquarters will be made later.

Business Items

A. P. Green Fire Brick Co., of Mexico, Mo., has opened an Eastern district sales office in New York City at 30 Church St., with Howard C. Thayer, formerly field mechanical engineer for the J. G. White Engineering Corp. at U. S. Nitrate Plant No. 2, in charge.

The Schenectady Power Co., the Mohawk Gas Co. of Schenectady, the Edison Electric Light and Power Co. of Amsterdam, and the East Creek Electric Light and Power Co. have merged into the Schenectady Illuminating Co. under orders passed by the public-service commission. The merger of the corporations has been under way for several years, and is a step in the proposed consolidation of the Schenectady Illuminating Co. and the Adirondack Electric Power Corp., which controls extensive hydro-electric power developments on the upper Hudson River. The latter consolidation is now pending before the commission. Electric-current distribution in parts of five counties—Schenectady, Rensselaer, Montgomery, Fulton and Herkimer—has now been brought under one management and control, resulting in greater distribution, improved service and reduced demands on auxiliary steam plants, operated with coal.

Trade Catalogs

The Corliss Carbon Co., of Bradford, Penn., has just published Bulletin No. 6, which gives complete up-to-date data on brushes in condensed form. A copy may be had by addressing the company.

The American Malleable Castings Association, Cleveland, Ohio, has issued a booklet entitled "Malleable Iron." This is only the forerunner of a more comprehensive volume to be issued later; nevertheless it is filled with valuable data. A copy will be sent gratis, on request, to anyone mentioning this paper.

Schweitzer & Conrad, Inc., of Chicago, Ill., has issued a catalog describing high-voltage protective and switching equipment. It is divided into five sections—Bulletins Nos. 101, 102, 103, 104 and 105. Bulletin No. 101 treats of fuses and switches; No. 102, circuit breakers; No. 103, cutouts; No. 104, lightning arresters; No. 105, detectors, relays and synchronoscopes.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8 05@8 35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2 15@2 75	$2 80@3 35
Philadelphia, gross tons	4 20@4 90	5 00@5 40
New York, gross tons	4 50@5 25	5 35@5 80
Alongside Boston (water coal), gross tons	6 10@6 85	6.90@7 65

Pocahontas and New River are quoted at $4 70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5 95	$7.80	Pea	4 80	6 55
Egg	5.85	7.70	Buckwheat	3 40	5 15
Stove	6.10	7.95	Rice	2 75	4 50
Chestnut	6.20	8.05	Barley	2 25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2 80 @ 3 10	2 95 @ 3 25
Clearfield County	2.65 @ 2.95	
Reynoldsville	2 65 @ 2 85	2 85 @ 2 95
Quemahoning	2 75 @ 2.95	2 95 @ 3.10
Somerset County (best grades)	2.75 @ 2.95	2.95 @ 3.10
Somerset County (poorer grades)	2.25 @ 2.50	2.50 @ 2.75
Western Maryland	2.25 @ 2.75	2.50 @ 2.75
Fairmont	2 10 @ 2 35	2 35 @ 2 50
Latrobe	2.10 @ 2.25	
Greensburg	2 35 @ 2 40	2 35 @ 2.60
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6.10	7.95	Boiler	2.50	3.50
Nut	6 20	8.05	Barley	2.25	3.15
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2 55	$2 55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2.30	....
2-in. lump	....	....	2.15

Williamson-Franklin rate to St. Louis is $1.07½; other rates 92½c.

New Construction

PROPOSED WORK

Mass., Foxboro—The State of Massachusetts is having plans prepared by R. D. Kimball Co., Engr., Beacon St., Boston, for the construction of a heating and power plant to be installed in connection with the 3-story, 50 x 160 ft. hospital which it plans to build on the State grounds here.

Mass., Springfield—The New York, New Haven & Hartford R. R., New Haven, Conn., plans to build a boiler plant at the freight yards here. Estimated cost, $25,000. E. Gagel, New Haven, Conn., Ch. Engr.

Conn., Bridgeport—H. E. Frank, 426 Boston Ave., will install a steam heating plant in the 4-story, 170 x 194 ft. apartment hotel which he plans to build on Washington Ave. and Coleman St. Total estimated cost, $200,000. E. B. Cladwell, 886 Main St., Arch.

Conn., New Haven—A. Gingold, 23 Church St., will install a steam heating plant and vacuum cleaning system in the 5-story, 73 x 110 ft. apartment hotel which he plans to build on Orange St. Total estimated cost, $100,000. C. J. Bailey, 94 Church St., Arch.

Conn., New Haven—The Marlin-Rockwell Corp., Whitney Ave., will install a steam heating plant and electric power in the 1-story, 160 x 180 ft. foundry which it plans to build. Total estimated cost, $100,000.

Conn., New Haven—A. D. Mullen, 42 Church St., will install a steam heating plant in the 4-story, 70 x 155 ft. apartment hotel which he plans to build on Crown and High St. Total estimated cost, $100,000. W. A. Donovan, 3 Colony St., Meridan, Arch.

N. Y., Attica—The Genessee Light & Power Co., Batavia, plans to issue $220,000 bonds; $88,000 of this amount will be spent for the construction of a power line from Batavia via Attica to Le Roy.

N. Y., Batavia—The Batavia Pure Ice and Storage Co., recently incorporated by P. J. Marion, F. W. Garnier and N. J. Schultz, has purchased the ice and storage plant of W. W. Buxton and will increase the capacity of ice-making machinery from 12 to 18 tons per day for its own use.

N. Y., Brooklyn—H. Spiegel, c/o the Sheffield Theater, 308 Sheffield Ave., will install a steam heating plant in the 2-story, 100 x 200 ft. theater which he plans to build on Stone Ave. near Pitkin St. Total estimated cost, $100,000. Zipkes, Wolf & Kudroff, 25 West 42nd St., Manhattan, Arch.

N. Y., New York—The Chicago Pneumatic Tool Co., 343 South Dearborn St., Chicago, Ill., will install a steam heating plant in the 12-story, 50 x 90 ft. office building which it plans to build at 6-8 East 44th St. Westinghouse, Church & Kerr, 37 Wall St., engr.

N. Y., New York—B. S. Moss Co., 729 7th Ave., will install a steam heating plant in the 2-story, 137 x 161 ft. theater which it plans to build on 181st St. and Broadway. Total estimated cost, $475,000. De Rosa & Pereira, 110 West 40th St., Arch.

N. Y., Oneida—The Building Committee of the Broad St. Hospital will install a steam heating plant and forced ventilating system in the nurses' home which they plan to build in connection with the hospital. Total estimated cost, $50,000.

N. J., Trenton—Essenwein & Johnson, Archts., Ellicott Sq., Buffalo, N. Y., will install a steam heating plant in the 9-story, 110 x 200 ft. hotel which they plan to build here. Total estimated cost, $1,000,000. O. E. Goldschmidt, 116 West 39th St., New York City, Engr. Owner's name withheld.

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install heating and humidifying apparatus in Building "D" here. Estimated cost, $75,000.

Penn., Tamaqua—The M & G Ice and Ice Cream Co. will soon receive bids for the construction of a 30-ton ice plant. Machinery and equipment will be installed in same. Estimated cost, $50,000. B. R. Stevens, 1737 Filbert St., Arch.

Md., Baltimore—The Standard Oil Co., Pier 2, Pratt St., will install a steam heating plant in the 6-story, 100 x 100 ft. oil storage warehouse which it plans to build. Total estimated cost, $200,000.

Md., Baltimore—C. M. Stieff, Inc., 9 North Liberty St., will install a steam heating plant in the 3-story, 25 x 110 ft. warehouse which it plans to build at 315 North Charles St. Estimated cost, $100,000. T. W. Pietsch, 1210 American Bldg., Arch.

Md., Baltimore—S. T. Williams, 223 North Calvert St., is in the market for a 150-hp. boiler with all fittings, 100 lb. pressure, return tube or water tube; also a 200 to 300 kw. generator or engine, direct connected, 250 volts D.C., D.C. Compound engine; also condenser and air pump, boiler pressure 100 lb., switchboard, instruments, etc.

D. C., Washington—The Municipal Architect, Room 10[illegible], District Bldg., has had plans prepared for the construction of a power house in connection with the new Gallinger Municipal Hospital which will be built here. Total estimated cost, $1,000,000.

Fla., Tallahassee—The city will rebuild the electric light and power plant recently destroyed by fire, entailing a loss of $50,000. C. S. Hammett, Jacksonville, State Engr.

Miss., Hollandale—The Commissioners of Black Bayou D.D., Greenville, will receive bids until May 13th for the construction of a 1-story pumping plant and concrete dam. Morgan Eng. Co., Goodwyn Institute, Memphis, Tenn., Engrs.

Ky., Louisville—The Louisville Water Co. is in the market for coal loading and carrying equipment and the latest labor saving machinery to be installed in the 75 x 150 ft. boiler house which it plans to build at the river pumping station. J. B. Wilson, Ch. Engr.

Ohio, Cleveland—The Board of Education, 340 Leader-News Bldg., will install a steam heating plant in the 3-story, 125 x 200 ft. high school which it plans to build on Lee Rd. Total estimated cost, $300,000. D. B. Carpenter, Pres. F. C. Warner, 768 Hippodrome Annex Bldg., Engr.

Ohio, Cleveland—H. S. Rivitz Co., 2112 Ontario Ave., will install a steam heating plant in the 3-story warehouse which it plans to build on East 40th St. and the N. Y. C. Ry. Total estimated cost, $300,000. C. Schwarzenberg, 1900 Euclid Ave., Engr.

Ohio, Cleveland—Van Aken & Strouck, 6523 Euclid Ave., will install a steam heating plant in the 4-story, 80 x 270 ft. auto sales building which it plans to build on East 66th St. and Euclid Ave. Total estimated cost, $250,000.

Ohio, Euclid—The Board of Education has awarded the contract for the construction of a 2-story school which it plans to build on Berwick Rd. to Drummond & Miller, Guardian Bldg., Cleveland. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ohio, Warren—The J. Warner Hotel Co. will install a steam heating plant in the 8-story hotel which it plans to build. Total estimated cost, $300,000.

Mich., Detroit—The Chicago Pneumatic Tool Co., 343 South Dearborn St., Chicago, Ill., will install a steam heating plant in the 5-story, 60 x 181 ft. office building which it plans to build here. Westinghouse, Church & Kerr, 37 Wall St., New York City, Engr.

Ill., Chicago—The Ravenwood Hospital Association, 1917 Wilson Ave., will install a steam heating plant in the 6-story, 150 x 200 ft. addition to the hospital on Winchester and Wilson Ave. Total estimated cost, $100,000. W. H. Pruyn, Jr., 122 South Michigan Ave., Arch.

Ill., Woodstock—The Oliver Typewriter Co. is in the market for a belt drive, single cylinder, horizontal air compressor.

Wis., Kenosha—The Board of Education will install a steam heating plant in the 2-story, 110 x 180 ft. school which it plans to build. Total estimated cost, $300,000. J. D. Chubb, 109 North Dearborn St., Chicago, Ill., Arch.

Ia., Des Moines—The Des Moines Water Co. plans to build a boiler house and will install a 300-hp. boiler and stokers. Alvord & Burdick, 8 South Dearborn St., Chicago, Ill., Engr.

Minn., Brainerd—The city will receive bids until May 8 for improvements to the waterworks. Project includes the construction of a pumping station with electric pump equipment. Total estimated cost, $250,000. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Consult. Engr.

Minn., Duluth—The United Yard & Terminal Association, 5823 Oneida St., will install a steam heating plant in the 3-story, 100 x 140 ft. building which it plans to build. Total estimated cost, $100,000. C. C. Randall, Pres.

Minn., Minneapolis—The Mill City Investment Co. will install a steam heating plant and fan ventilating system in the 3 story, 110x127 ft. theatre and hall which it plans to build on Lake St. near Nicollet St. Total estimated cost, $100,000. D. C. Swain, Plymouth Bldg., Arch.

Minn., St. Paul—The North American Casket Co. will install a high pressure boiler, dry kiln, etc., in the 1-story, 50 x 230 ft. factory which it plans to build. Total estimated cost, $50,000. H. Firminger, 408 Oppenheim Bldg., Arch.

Minn., Winona—The city plans to install additional water supply facilities, to consist of air lift pumps and compressors. Alvord & Burdick, 8 South Dearborn St., Chicago, Ill., Engr.

Kan., Sedan—The Sedan Electric Light & Power Co. plans to build extensions to its power plant. Estimated cost, $32,000. Address M. W. Hartzell.

Neb., Lincoln—The city voted $100,000 bonds for the construction of a main intercepting sewer. Plans include the installation of centrifugal pumps or ejectors. A. Dobson, 945 D St., City Engr.

Neb., Omaha—The Board of Education will install a heating and power plant and probably 4 boilers in the new High School of Commerce which it plans to build. F. W. Clark, 623 Brandeis Bldg., Arch.

N. D., Fargo—The city voted $150,000 bonds for the construction of a light plant. F. L. Anders, City Engr. Noted Mar. 18.

Mont., Ronan—C. C. Beach has been granted a franchise to build an electric light and power plant.

Mo., St. Joseph—The Conser Laundry, 908 Francis St., is in the market for an entirely new power plant, to consist of 2 boilers of tubular type, 18 x 72 ft., 1 direct connected generator unit, 2 pumps, a feed water heater, a water softening plant and other appliances such as oil burners, 12,000 gallon oil tank, etc. H. S. Lewis, Ch. Engr.

Mo., St. Joseph—Swift & Co., Union Stock Yards, Chicago, Ill., plans to build 2-story, 40 x 51 ft. addition to its boiler room here. Estimated cost, $50,000.

Ariz., Phoenix—The High School Trustees plan election to vote on $100,000 bonds for improvements at the high school. Plans include the construction of a new heating plant. Estimated cost, $25,000.

Ont., Ottawa—The Hydro-Electric Commission, 109 Bank St., will soon award the contract for transformer, meters and general electric supplies. Estimated cost, $12,000. J. E. Brown, Engr.

Ont., Toronto—The Polusterine Products Co., 170 Ontario St., is in the market for a 25 hp. steam boiler, 2½ hp. electric motor and a 150 gallon steam kettle.

Ont., Welland—The Provincial Government has authorized bill for the construction of a hydro-electric power line from Welland to Port Colborne via Crystal Beach, Ridgeway to Fort Erie and thence to Niagara Falls. Sir Adam Beck, Minister of Power.

Ont., York—The city will vote on by law April 15 for $200,000, to be used for extension of hydro-electric system high tension lines, distributing system and operation.

H. T., Pearl Harbor—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to improve the power plant here. Estimated cost, $80,000.

CONTRACTS AWARDED

Ind., Marion—The city has awarded the contract for installing a 2000 cu.ft. air compressor in connection with extending and improving the wells at the waterworks to Laidlow-Dunn-Gordon Co., Cincinnati, O.

Ill., Chicago—The Illinois Packing Co., 3940 Normal Ave., has awarded the contract for the construction of a meat packing plant on Auburn and 38th St. to J. Rodatz, 209 South La Salle St. Plans include the construction of a 1-story, 50 x 60 ft. power house and refrigeration plant. Total estimated cost, $225,000. Hensheim & McLaren, 37 West Van Buren St., Arch.

Cal., Los Angeles—The Clunes Production Co., 5350 Melrose Ave., has awarded the contract for the construction of a 1-story, 20 x 74 ft. electric shop and generator room and a 1-story, 80 x 150 ft. motion picture stage, to E. Fossler, 6434 Hollywood Blvd.; 2 electric generators will be installed in same. Estimated cost, $15,000.

Cal., San Jose—The Richmond Chase Co. has awarded the contract for the construction of a power house, warehouse, cannery, etc., to Z. O. Field, 167 South 14th St.

Cal., Seal Beach—The city has awarded the contract for the construction of a complete sewer system to Mlagenovich & Gillespie, 219 Bloom St., Los Angeles. Plans include the installation of a rotary pump and motor and 2 auxiliary booster pumps. Estimated cost, $42,000. Noted Mar. 4.

Opportunities!

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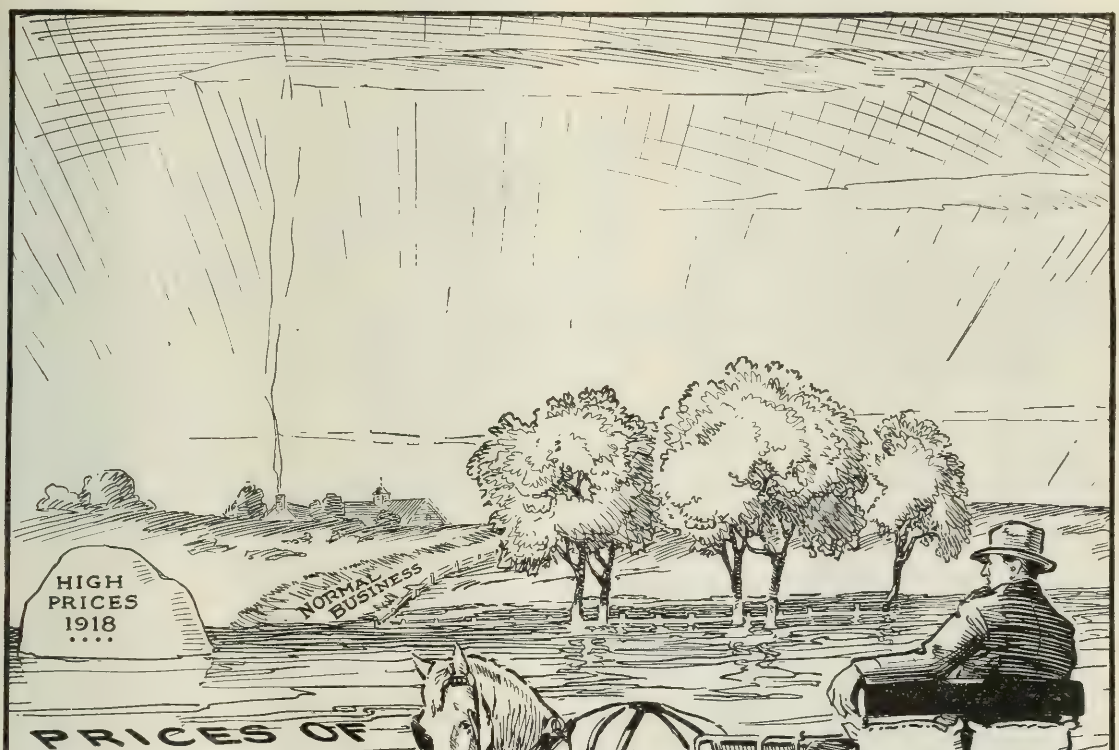
See pages 87 to 95

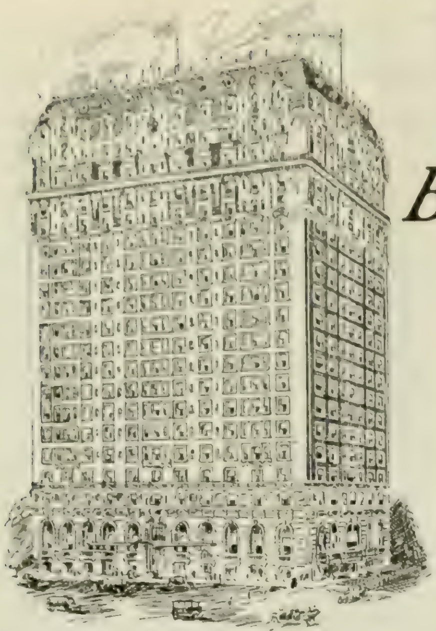
—the "Opportunity" Center of the Power Plant Field.

POWER

Volume 49 New York, April 29, 1919 *Number* 17



He is faced by the prospect of a long wait, unless he decides to disregard the flood and drive through



Saving Coal in the Blackstone Power Plant

By W. A. Eberman*

Remodeling of the boiler furnaces together with the coöperation of the operating force and the intelligent use of instruments resulted in a saving in fuel amounting to 12 per cent. One of the greatest features incorporated was the improved furnace conditions brought about by the installation of a type of stoker that was guaranteed to operate with an efficiency of 70 per cent under normal operating conditions. The efficiency of the men was mainly the result of explaining things to them and what was expected to be accomplished.

IN THESE columns the power plant of the Blackstone Hotel has had previous mention. The present article has to do with a 12.3 per cent. saving in fuel. Last year the coal consumption was 1543 tons less than the average for a period of six years. In other words, the average consumption of 12,561 tons of coal was reduced to 11,018 tons. The saving was due to a change in boiler-room equipment made desirable by the rising cost of fuel, to better coöperation from the operating force and intelligently directed support from the management of the hotel. One of the greatest factors was improved furnace conditions. The stokers originally installed had never been entirely satisfactory, owing principally to deviations from standard design to conform with space limitations. War-time prices for coal emphasized their deficiencies and led the management to substitute stokers better suited to the requirements. The results of tests made on duplicate boilers, show that the change was justified.

TEST RESULTS FROM OLD AND NEW FURNACES

	Old Furnace	New Furnace
Time, hours, minutes	7	8–14
Total water evaporated, lb	86,784	101,232
Temperature feed water, deg. F	210	210.9
Coal burned, lb	11,902	11,763
Apparent evaporation, coal as fired, lb	7.29	8.6
Equivalent evaporation, coal as fired, lb	7.65	9.03
B.t.u. coal	11,900	12,179
Efficiency, per cent.	62	71.5

Corrections are not made for quality of steam in either test. The coal cost of 1000 lb. of steam at the prevailing price of $3.15 per ton was 21.6c. with the old grates and 18.4c. with the new stoker. The ratio of the efficiencies obtained is within 1 per cent. of the ratio of the annual coal consumption figures given at the beginning of the article.

The duty of the plant is to furnish lighting, power, heating, ventilation, elevator service, air and icebox refrigeration, ice for the kitchen and restaurants, water and laundry service for a hotel of 425 rooms. The adjoining theater, and the help's dormitory are heated and lighted from the hotel plant. Exhaust steam is sufficient for heating purposes when the temperature is above 20 deg. F., live steam being needed to supplement the exhaust when the temperature is lower. As this article is to deal primarily with the boiler room, the steam-using end of the plant may be passed over with the statement that it contains the necessary apparatus to supply the services previously mentioned, and is considered modern.

The steam load is greatest in winter, when it reaches a maximum of 1200 boiler horsepower and is practically the same day and night. The temperature determines the load after 20 deg. F. is reached. When air refrigeration is required to cool the restaurants, the summer load is about 850 hp. on two shifts and 300 to 350 hp. on the third shift. Between these seasons the load is around 750 hp. for two-thirds of the day, which in

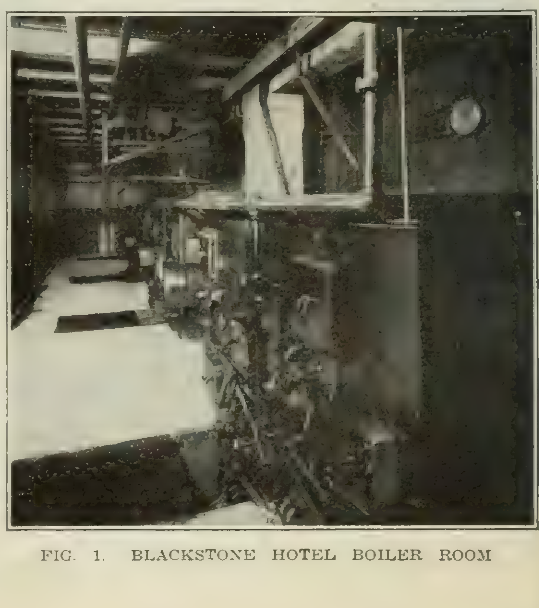


FIG. 1. BLACKSTONE HOTEL BOILER ROOM

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*Chief engineer, Blackstone Hotel.

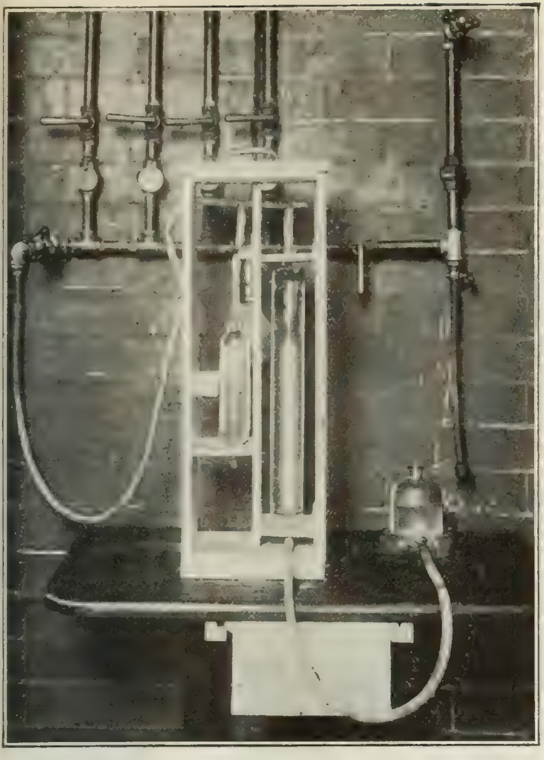


FIG. 2. CO_2 ELEMENT FOR USE OF FIREMEN

hotel work is always a full 24 hours. For the balance of the time the requirements are the same as the midnight-to-morning load in summer. The load varies from day to day as well, being affected by the volume of business.

The boiler plant is made up of four 250-hp. water-tube boilers equipped with side-feed stokers. The boilers are set singly with a scant two feet between them and are connected with a long breeching to a stack that rises 328 ft. above the grates, giving more draft than is needed.

Individual dampers, with the controlling rods brought to the front of the boilers where they are convenient to the fireman, control the air supply. Draft gages are mounted on the front of each furnace. Mechanical soot blowers have been installed recently, but have not been in use long enough to have had much influence on the figures previously given. Coal is taken from overhead bunkers by means of an electrically driven weigh hopper and delivered to the furnace without the necessity of shoveling. Coal weights are recorded on suitable forms by the fireman on each watch and checked against the venturi meter on the feed line. The boiler settings are good, and a rigid inspection with prompt repairs keeps air leakage to a minimum. Elastic coating on the brickwork and sealed clean-out doors help in this.

With conditions as outlined, the highest everyday efficiency with the old furnaces was about 60 to 61 per cent. Many attempts were made to improve these figures but without success. When the load was just right, which was a small part of the time, fair results were obtained. The trouble seemed to be lack of air control and flexibility. Light loads meant short fires and low economy. Heavy loads on the shortened grates meant thick fires and heavy drafts which pulled in air around the end of the grates and along the sides where the fuel burned away faster than at other points. There was not sufficient space between the settings to work the fires from the sides. The short grates called for No. 3 or No. 4 washed nut of good quality. Moderate loads could not be handled with screenings or other comparatively slow-burning coals. Another thing that lowered the over-all efficiency was the necessity of keeping a third boiler ready to work at all times, even when two boilers would handle the load.

The stokers were ordered with a guarantee of 70 per cent. efficiency under normal operating conditions. The first unit was started in September, 1916, and after a short run a test was made by the operating force that showed an efficiency of 71.5 per cent. at 50 per cent. overload. A second furnace was dismantled as the material for its replacement was shipped, but it was lost in the freight congestion that occurred at that time, and did not reach the plant until late in January, 1917. In October, 1916, the coal situation became serious, and from that time until spring it was necessary to take any kind of coal that could be obtained. The heating load came on and there was many an anxious moment with steam at a point dangerously near the shutting-down point. The old furnaces could do little with the fuel available, and the brunt of the work fell on the one new stoker that had been installed. These conditions prevailed until early in February, when the second stoker was ready and the troubles were over, as the two would carry the entire load, which at one time for a week of very cold weather held steadily around 1200 boiler-

FIG. 3. COAL BULLETIN BOARD

horsepower. The last of the four new stokers was installed in October, 1917.

During last summer one boiler was made to carry the entire load for a period of a week to determine the limit of its capacity. The load during two shifts was 700 hp., and there was no special difficulty in keeping up the pressure. Complete data were not secured during this run, but it was noticed that the CO_2 was uniformly high—higher in fact than was desirable, 16.5 per cent. being easily obtained. The evaporation was somewhat lower on the two heavy shifts for the uptake temperatures were high. Better results were noticed during the light-load period when the load dropped to around 350 hp. The conclusion drawn was that the grate area was excessive, and three of the grates have been shortened. It is planned to cut them down still further, and run that way until winter. A large reserve capacity is at hand for emergency.

The new outfit has demonstrated its ability to carry heavy overloads, to burn grades of coal inferior to that used regularly—No. 4 washed nut—and to burn them efficiently. There was not much variation from the guaranteed efficiency of 70 per cent. even when burning screenings, as was necessary during periods of coal shortage last winter and at the request of the Fuel Administration last summer. Burning screenings was profitable when the price of coal was low and the difference in the price of washed coal and screenings was relatively greater, but with a difference of only 40c. and the price per ton $5.60, there was no inducement to continue with this fuel, for screenings are harder to handle, make more ash and foul the heating surfaces more than washed coal.

CREDIT DUE TO THE BOILER-ROOM CREW AND WATCH ENGINEERS

For the saving made, credit is due to the interest taken by the boiler-room crew and the watch engineers in making the new equipment live up to expectations. The chief engineer claims only the credit of procuring and holding a set of men who have coöperated with him so well. In his opinion the secret of getting intelligent men to strive for high efficiency is to keep them informed as to the aims of the management, letting them know the results they are getting and giving them credit for their efforts. A reward in money cannot always be given, but appreciation can be shown and the men impressed with the fact that they are a real part of the business. The firemen like to know the reasons for things that involve a departure from their accustomed methods, and they have a right to know. It has been the policy in this plant to explain things to the men—what is expected to be accomplished, what it means to the hotel in general and to the reputation of the department in particular. A complete set of records is kept, not locked in a vault, but placed in a wall case open to the inspection of any employee at any time, and they watch them, too. An elaborate bulletin board ruled in columns is placed in the boiler room. The first column shows the coal burned the day before, the second the consumption during the corresponding day of the previous year, the third column the gain over the previous year and the fourth the loss, if any. Recently, there has been no use for the last column.

For years an Orsat has been used on special occasions, but when the new installation was started the outfit was rebuilt to make it easier to operate and lines of permanent piping were carried from each boiler to a point in a pleasant place where the work could be done in a comfortable manner. A sample of gas is drawn quickly through pipes of ample size by the house vacuum system and then through the burette by the same means. The system of valves is such that it is only a moment's work to switch from one boiler to another, bringing over a fresh sample while the one in the machine is being analyzed. Recently, a duplicate of the outfit just mentioned has been permanently installed at the entrance of the boiler room, for the exclusive use of the firemen, who have readily learned to use it and to make use of the readings they get. It shows its value in the evaporation column of the daily log and on the bulletin board.

Double-Service Boiler

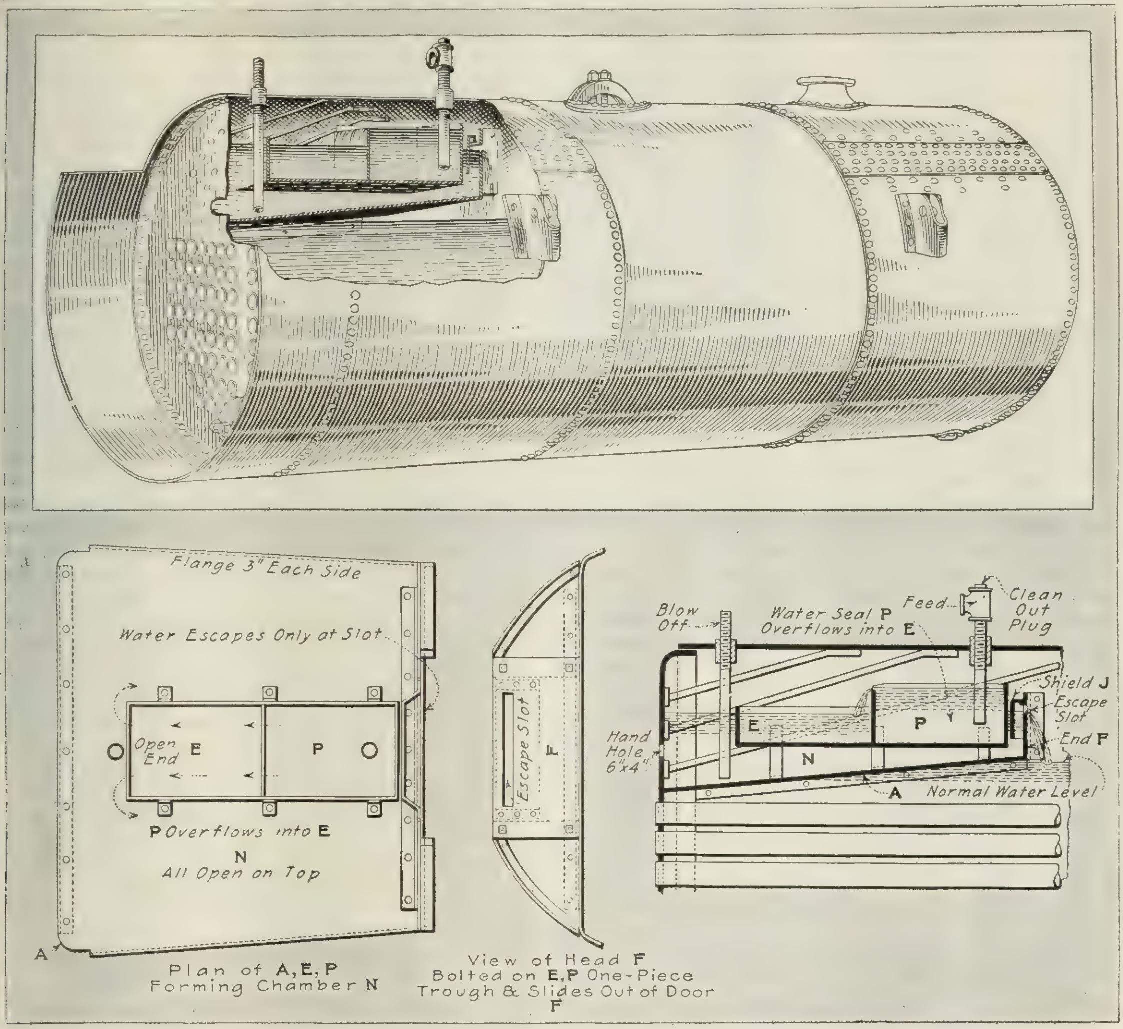
A new method of separating scale-forming solids, mud, oil or other foreign matter (with the exception of common salt), such as is commonly found in stationary power steam boilers is illustrated herewith as applied to a horizontal return-tubular boiler. The apparatus consists of a live-steam feed-water purifier located in a horizontal fire-tube boiler, which may be of the locomotive, Scotch or horizontal return-tubular type.

In the construction of the purifier first a plate *A* is attached to the front head with an angle iron and the flanged sides are attached to the shell with a few rivets, the joints being made tight with metal cement. Above the plate *A* is a trough *E P* supported on legs attached to the plate *A* in such manner that the trough can readily slide out. This trough is open at the end nearest the boiler head and closed at the opposite end. It is in two parts, one being a water-seal box *P* in which the feed water discharges. In the water-seal box the water escapes into *E* by overflowing through the steam, thus quickly increasing its temperature to that of the steam. From the end of *E* the water reverses and flows forward to the escape slot, which discharges into the boiler in a thin film. In front of the escape slot a shield *J* is provided that causes the water to underflow the shield in escaping through the slot into the boiler proper. This operation is simple. Assume the water level to be in line with the slot, then water added by the feed raises the level and water escapes from the slot in an equivalent amount, and this process proceeds constantly.

At the head end containing the slot a door is provided and is attached with bolts having their heads spot-welded on and provided with brass capnuts so arranged that the door is easily removable, thus enabling the trough *E P* to be slid forward. By removing the internal feed pipe, the trough may be readily withdrawn for cleaning, inspection, etc.

Since no portion of the fire strikes the parts of the purifier, it follows the deposits therein being in water do not bake on as they would in the boiler, but remain as mud easily blown out through the blowoff pipe. In addition, a handhole provided in the front head affords an opening for cleaning, inspection, etc.

The value of the underflow method of escape is based on the way the calcium solids are liberated and become insoluble or in suspension. The carbonates and sulphates are in solution owing to carbonic and sulphuric acids respectively. When heated sufficiently, these gases separate from the atoms of calcium and rise to the surface of the water and escape as gases. The atoms are carried to the surface in this progress and remain there until finally they accrete together and by gravity fall to the bottom, since the shield *J* prevents all flocculent floating matter escaping from the purifier. Carbonates are set free at lower temperatures than sulphates, the latter being liberated at or under 280 deg. F., which is the temperature of steam at 50 lb. absolute, or 35 lb. gage pressure. The purifier receives and absorbs heat from the water on its bottom sheet, also on the surface of the water and at the overflow from the water-seal box *P* into *E*. The result is that the feed water, when it escapes through the slot, is about as hot as the water in the boiler proper.



DOUBLE-SERVICE BOILER AND DETAILS OF FEED-WATER PURIFIER

The diagonal braces are not interfered with in any way, and the steam room remains ample, in fact is greatly in excess of that of water-tube boilers. Foaming cannot occur since the cause, flocculent matter, is removed. The purifier is an integral part of the boiler and has no upkeep charges and requires no repairs at any time in the life of the boiler.

Carbonates, sulphates, magnesia, mud and oil are retained in the purifier just as otherwise they would be retained in the boiler. The purifier can be blown down readily at any time while the boiler is under pressure.

Consider the scale problem. Take a 200-hp. boiler running 24 hours per day, 30 days, using water containing only 15 grains per gallon. At the end of the run, there would be over 1100 lb. of lime deposits. Boiler-insurance experts say that over 50 per cent. of the boiler accidents are chargeable to foreign matter, scale, etc.

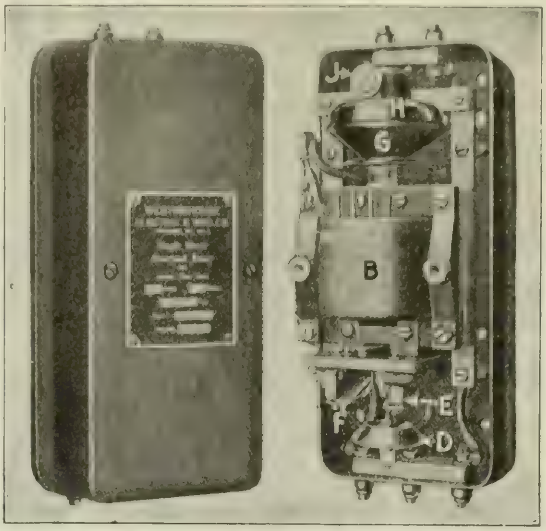
It is contended that not only does the "double-service boiler" purify the feed water at small expense, but also by preheating the feed water the boiler is not subjected to the expansion and contraction stresses of the common methods of feeding. The apparatus complies strictly with paragraph 315 of the A. S. M. E. Boiler Code as respects an auxiliary feed-water heating and circulating device, also with paragraph 316 as respects the feed not discharging near riveted joints in the shell or furnace sheets.

The designer and patentee of the Double Service Boiler is Thomas T. Parker, of Brooklyn, N. Y.

Alternating-Current Plunger-Type Relays

By VICTOR H. TODD

THE great need of continuous service under all conditions has gradually caused the crude types of relays of a few years ago, which sometimes gave protection under special conditions but often failed at the critical moment, to be changed to the highly developed present-day types, which are built with the accuracy of a watt-hour meter and can be depended upon in practically all conceivable cases of electrical distress. In alternating - current systems, the need of continuity of service is so great that the lines must be kept alive until there is no chance of the disturbance clearing itself. In some states the public utility boards require an explanation of each and every interruption that occurs in an operating company's service as well as a report of the steps taken to prevent its recurrence.



FIGS. 1 AND 2. INVERSE TIME-LIMIT RELAY COMPLETE AND WITH COVER REMOVED

Many power-plants and factory managements have required in the past duplicate supply lines, so that their power supply would not be interrupted in case of trouble on other parts of the system. Others have maintained stand-by plants ready to assume the load in case of electrical trouble.

As a typical example of how protective relays have eliminated this necessity, one operating company had as many as 25 interruptions a year, but after making an intelligent survey of the system, a few changes were made in the sectionalizing apparatus and accurate relays installed which reduced the interruptions to about one annually, although the system suffered not less than one hundred short - circuits per year from various causes.

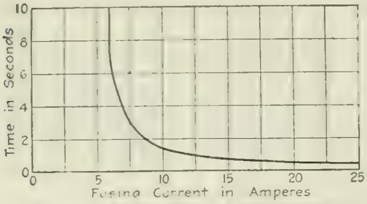


FIG. 3. TIME CHARACTERISTICS OF A FUSE

The relays instantly sectionalize and isolate a defective line or piece of apparatus without disturbing the rest of the system. This allows spare lines to be used continually, and the great saving and economy of copper will often finance the installation of relays.

Before describing the various types, or deciding on a certain system of protection, it is well to consider the basic principles of protection. What is an interruption? How long may an overload exist? How long can a short-circuit exist before it must be cleared?

An interruption occurs when the voltage ceases long enough to cause an induction motor to reduce its speed so far that it will draw an excessive current should the potential be applied suddenly, or when synchronous apparatus falls out of step. This time is usually about two seconds, so it is evident that a "dead" short-circuit must be cleared in two seconds or less. Moderate overloads of a few hundred per cent. need not be cleared so quickly, as modern generators are built with enough overload capacity to withstand considerable overload without damage. Consequently, in a simple circuit requiring protection, the time between the instant of overload and the opening of the breaker should be inversely proportional to the excess of current. An ordinary fuse gives this desired inverse-time limit to some extent, as will be seen by referring to Fig. 3. It will be noted that a current of 5 amperes will not blow the fuse, 6 amperes will blow it in 6 sec., 7.5 amperes in 3 sec., 10 amperes in 1.25 sec., 20 amperes in 0.5 sec., etc.; but above this value the time becomes practically instantaneous. It is obvious that instantaneous operation on a short-circuit is not always desirable, as the short may burn out or clear itself in less time than it takes to cause a loaded motor to slow down appreciably.

[Note: The terms circuit-breaker and oil switch are used synonymously in this article.]

The first circuit-protecting relays were made with an inverse time limit. In other words, instead of the load current acting directly on the oil switch and opening it instantly in case of trouble, the excess current operated a relay, which, after a predetermined time, opened the circuit-breaker.

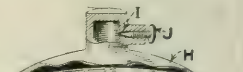


FIG. 4. SCHEMATIC DIAGRAM OF RELAY FIGS. 1 AND 2

Fig. 1 shows a typical overload relay which obtains the time limit by means of an air bellows. Fig. 2 shows the same relay with the cover removed, and Fig. 4 is a schematic diagram of the same. The iron plunger *A*, working under the influence of the solenoid *B*, carries at its lower end an insulated disk *D* having on its circumference a band of nonoxidizing metal. When the solenoid coil *B* is energized by a current of a certain strength, the core *A* is pulled upward, thus forcing the disk *D* against the contacts *E* and *F*, completing a circuit to a shunt-trip coil on a circuit-breaker. On the upper end of the plunger shaft is a leather bellows *G* fastened to the permanent support *H*, so that as the plunger rises, it compresses the air in the bellows and resists its upward motion. This air is permitted to escape gradually through a little opening at *I* in the casting, and this gradual escape of air allows the plunger to rise in a certain time to complete contact at *E* and *F*. These parts are also indicated in Fig. 2.

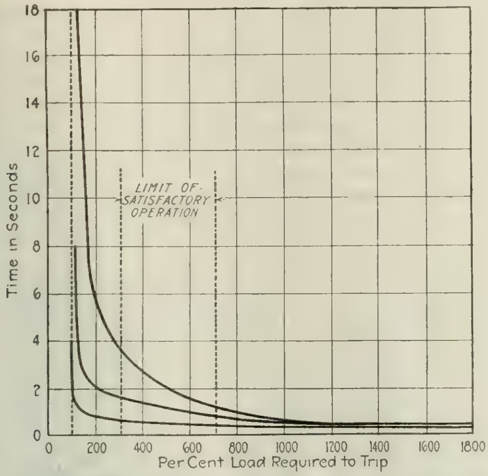


FIG. 5. TIME CHARACTERISTICS OF BELLOWS-TYPE OVERLOAD RELAY

It is evident that the greater the current in the solenoid *B* the greater will be the upward pull, consequently the greater the compression in the bellows, the quicker the escape of air and the shorter the time. That is, the greater the overload the quicker the circuit will be opened.

This inverse proportion is not a fixed factor, however, since by varying the size of the escape aperture at *I* by means of the valve *J*, the time may be varied from almost nothing to 15 or 20 sec., and still have the inverse time limit.

The taps *K*, *L*, *M*, etc., are provided to change the number of turns in circuit and consequently the amount of current required to operate the relay. For instance, this particular relay has taps for 4, 5, 6, 7 and 8 amperes. This means that if the 4-ampere tap is in circuit, the plunger will start to rise when the current reaches 4 amperes; with the 5-ampere tap, the plunger will rise when the current reaches 5 amperes, etc.

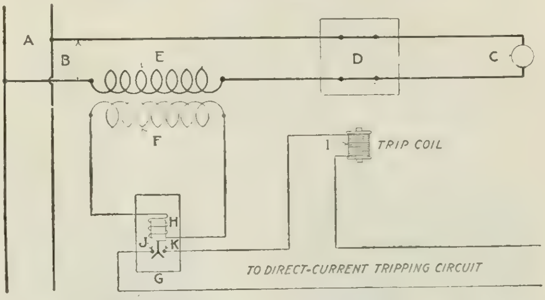


FIG. 6. DIAGRAM OF RELAY CONNECTIONS ON SINGLE-PHASE CIRCUIT

As a practical example, assume that the relay is used with a 100 to 5 current transformer. This means that when the full-load current of 100 amperes is reached there will be 5 amperes passing through the relay coil. But if connections are made with the 4-ampere tap, the relay will operate on 4 amperes, which, in the ratio of 5 to 100, means that it requires only 80 amperes to operate the relay with this setting. Should the 8-ampere tap be connected in, the relay will not operate until there is a load of 160 amperes on the primary of the transformer. This might take 18 sec. to trip the oil switch. But with the same setting, a load of 300 amperes might take only 4 sec.; 600 amperes 1.5 sec.; 1000 amperes 1 sec.; and so on in time inversely proportional to the current.

This inverse time is not a straight-line inverse time,

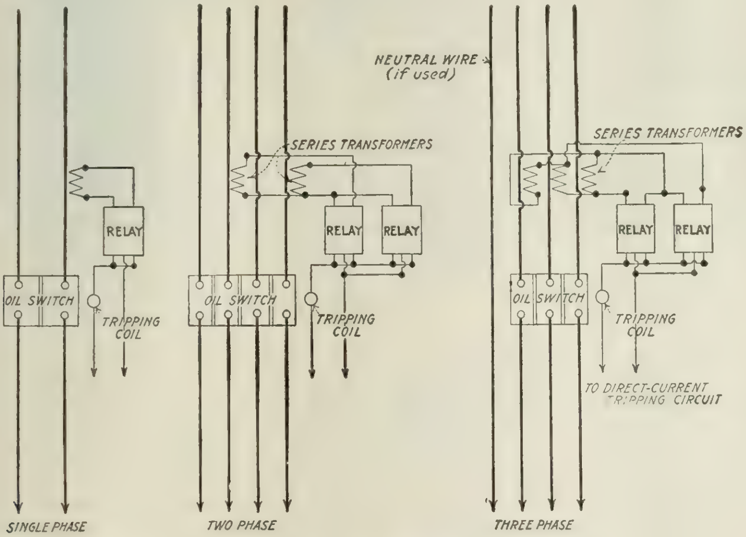


FIG. 7. DIAGRAMS OF RELAY AND TRANSFORMER CONNECTIONS FOR A DIRECT-CURRENT TRIPPING CIRCUIT

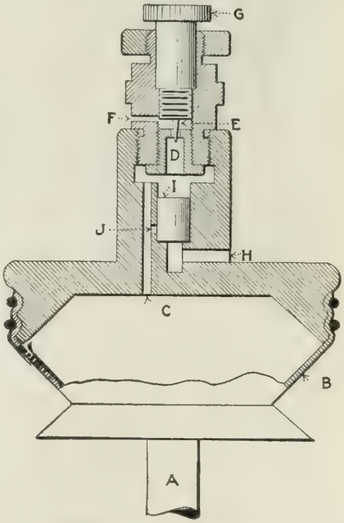


FIG. 8. RESETTING DEVICE ON RELAY SHOWN IN FIG. 9

but follows a curve such as that shown in Fig. 5. It will be noticed that this curve is very similar to the time curve of a fuse, but has the distinct advantage that it may be varied at will, and the relay is accurate and can be depended upon, and is automatically reset each time it operates.

One relay is necessary for the protection of a single-phase circuit and two for a two-phase or a three-phase circuit. Fig. 6 shows the diagram of connections of a single-phase circuit. *A* is the busbar supplying the feeder *B*, which in turn supplies the load *C*, and the circuit-breaker *D* opens and closes the circuit. *E* is the primary winding of a series transformer and *F* the secondary, which is connected to the relay and energizes the solenoid *H*. The direct-current circuit is connected to the shunt-trip coil of breaker *D*, with a break in the circuit at contacts *J* and *K*. This diagram shows the normal operating position.

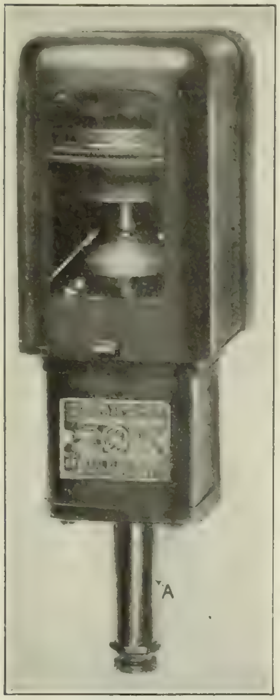


FIG. 9. INVERSE TIME-LIMIT OVERLOAD RELAY

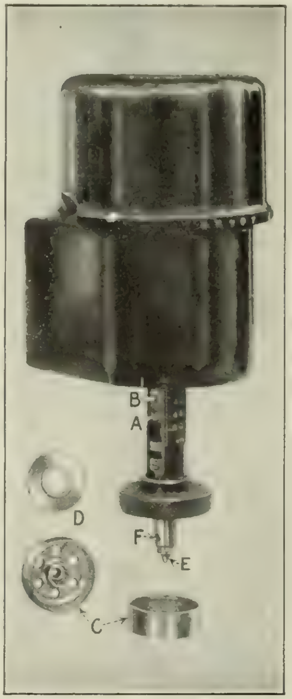


FIG. 10. SHOWS DASHPOT DETAILS OF RELAY, FIG. 11

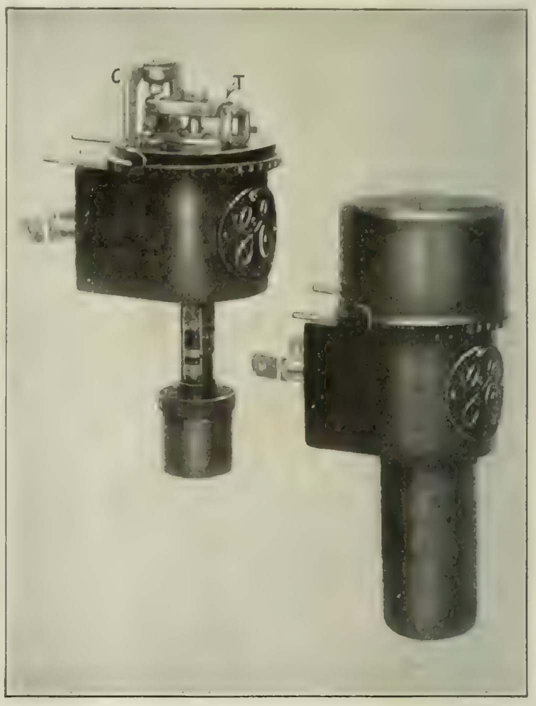


FIG. 11. DASHPOT-TYPE INVERSE TIME-LIMIT RELAY WITH COVERS REMOVED AND IN PLACE

If an overload occurs at *C* and excess current in the transformer *EF* results, the relay plunger rises, short-circuits the contacts *JK* and completes the trip circuit; an instant later the oil switch will open, disconnecting the line. Fig. 7 gives diagrams of relay and transformer connections for protecting single-phase, two-phase and three-phase circuits.

Another bellows type of relay is shown in Fig. 9. This is a single-phase unit, but they are also made with two and three relays mounted on one casting to protect two- or three-phase circuits. However, they will require two or three separate series transformers just as the relays previously described will. It will be noted in this type that the contacts are at the top, and protected by a removable cover, permitting ready inspection.

In this relay the various load settings are not obtained by taps, but by varying the position of the iron plunger in the solenoid by an adjustment at *A*. Lowering the plunger requires more current to raise it, and raising the position requires less current.

The time setting is varied by an air valve in the top of the bellows casting, as shown in Fig. 8. When an overload occurs, the solenoid raises the plunger, thereby raising the stem *A*. This compresses air in the leather bellows *B*, forcing it up the channel *C*, through the valve *D*, past *E* and out at *F*. The time is adjusted by varying the position of the pin *E* by turning *G*. A good feature is the quick-resetting device shown at *H* and *I*. *I* is a cylinder which, on upward travel of the stem *A*, is forced against opening *H* and effectually closes opening *J*. When the relay attempts to reset, the air is rarefied in the bellows and cylinder *I* is lifted, allowing air to enter *H* and *J*, thereby insuring a quick resetting of the plunger.

One drawback to the leather-bellows type relay is that the leather, unless attended to carefully, will harden in time and crack, thus defeating the purpose of an accurate time. To overcome this, relays of the type shown in Figs. 10 and 11 have been developed. These have the contacts at the top, as in the type Fig. 9, but the bellows is omitted and an oil dashpot is placed at the bottom of the stem as shown in Fig. 11.

Instead of forcing air through a needle valve, oil is forced by a piston on its upward travel through the valve *E* and out of hole F, Fig. 10. The piston *C* has a number of holes in the bottom, which are normally covered by the disk *D*. Upon upward travel the disk closes the holes practically oil-tight, but on downward travel it rises and allows a quick resetting of the plunger.

These relays cannot be used where they are subjected to extreme changes in temperature, and no other oil except that supplied by the manufacturers should be used in the dashpot. Their time may be varied from almost instantaneous at heavy loads, to over 5 min. at 150 per cent. load.

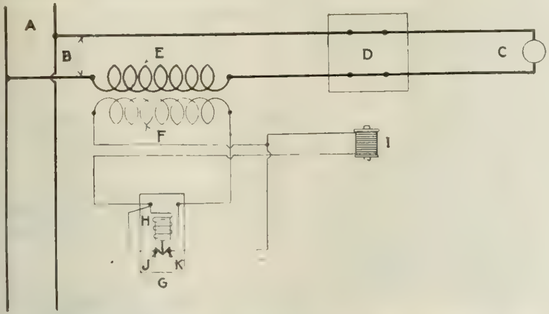


FIG. 12. DIAGRAM OF CONNECTIONS FOR SERIES-TYPE INVERSE TIME OVERLOAD RELAY

Sometimes, as in radial systems an inverse time is not so desirable as a definite time. To obtain this, the relays heretofore shown are slightly modified so that instead of the plunger being rigidly attached to the bellows and contact shaft, the raising of the plunger merely compresses a spring, which in turn raises the shaft. This is shown in Fig. 13. The plunger *A* is free to slide up on the shaft *N*. When it rises, it compresses the spring *O*, which presses against a stop rigidly attached to the shaft, at the bottom of the bellows, thereby rising in the shaft and contacts.

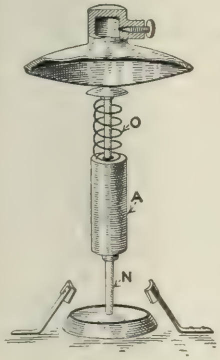


FIG. 13. DEFINITE TIME LIMIT OVERLOAD RELAY

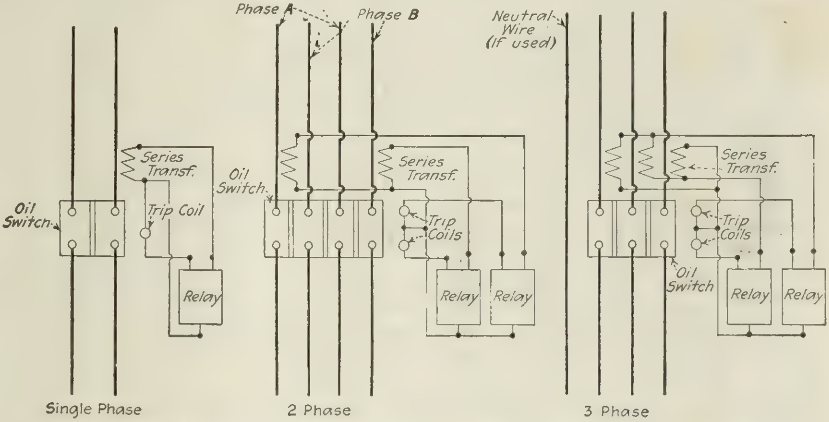


FIG. 14. DIAGRAMS OF RELAY AND TRANSFORMER CONNECTIONS FOR SERIES-TYPE RELAY TRIPPING CIRCUITS

It will be readily seen that no matter how much current is passed through the solenoid, once it rises, there can be no greater compression from the spring no matter what the load. Consequently, the contacts are closed in a definite time, depending upon the time setting after the raising of the plunger. Hence the name, "definite time-limit overload relay."

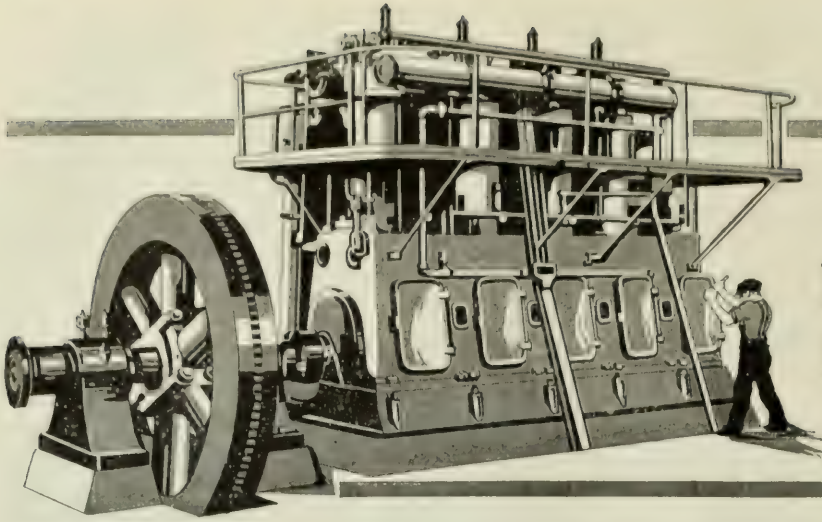
In the examples shown, it was assumed that there was always a separate direct-current circuit which the relay completed to trip the oil switch. Sometimes a source of direct current is not available, so the secondary current of the series transformer is used to trip the circuit-breaker. These relays are known as series-trip or circuit-opening types. The secondary of the transformer is connected to the trip coil on the breaker, but this coil is short-circuited normally by the relay contacts. When the relay operates, it connects the trip coil in circuit, thereby causing all the current to flow through it and open the oil switch. This is shown in Fig. 12, in which the feeder *B* is supplying the load *C* through the current transformer's primary *E* and protected by circuit-breaker *D*. The secondary of the transformer *F* is connected through the relay *H* and the trip coil *I* on the oil switch *D*. The trip coil is short-circuited by the contacts *J* and *K* on the relay. An overload at *C* causes excessive current to flow in the relay coil *H*, which raises its plunger and opens the contacts *J* and *K*, causing current to flow through the trip coil *I*, which opens the oil switch. Fig. 14 gives diagrams of relay and transformer connections for protecting single-phase, two-phase and three-phase circuits.

The series-trip relays have an advantage in that they do not require a separate circuit to trip the circuit-breaker. However, unless they are equipped with solidly closed contacts, they are liable to trip the breaker on a slight jar or knock.

One type of series-trip relay, Fig. 11, closes the contacts *C* by a toggle *T*, which is closed on the downward travel of the plunger, thereby insuring very positive connection. When the plunger rises, this opens the toggle, allowing a spring to open the contacts with a quick positive action. It is possible to combine the advantages of a definite-time and an inverse-time relay in a single unit, which is made on the same lines as a watt-hour meter and has watt-hour meter accuracy, but has not the torque necessary to operate a toggle. This type will be discussed in a future article.

According to the Bureau of Mines, volatile combustible containing a high percentage of oxygen appears to be more difficult to burn than that which has a low oxygen content. Whether this is due to the oxygen or to some other chemical property has not been determined.

When wood is used as a boiler fuel, the great problem is to reduce the excess air, because wood does not make a compact fire bed. Sawdust used with wood will aid in producing a more uniform thickness of fire.



Talks on DIESEL Engines

by L. H. Morrison

XV—The lubrication of crankshaft bearings, crank pins, piston pins, pistons and helical gears forms an interesting subject for the evening's discussion.

"DARN the cuss that invented chain oilers!" exclaimed Kelly with deep feeling. "I wish he'd strangled to death on his nursing bottle."

The silence of the rest indicated tacit approval of his sentiments. A main bearing on one of the 500-hp. engines had run hot that day and had to be rebabbitted, and the men were tired.

"Why are chain oilers used, anyway?" Kelly appealed to Egan. "I'd think a ring oiler'd be just as good, and it wouldn't break."

"To answer that demands a rehash of bearing lubrication," said Egan. "Many builders prefer a bearing with an oil cellar and one or two rings resting on the crankshaft. As the shaft turns, the rings draw oil up and deposit it on the shaft. This design is all right for shafts under 8 in. in diameter, but above that their use is objectionable."

"Chief," Woods interposed, "I'd think that the larger the shaft the more positive you'd be that the rings would revolve."

"The objection isn't due to the ring not revolving, but to the width of bearing," Egan explained. "With a shaft 9 in. in diameter, at least 6 in. of oil should touch the ring. Furthermore, the oil level can't be as high as the bottom bearing shell or it will leak out at the end of the bearing. The ring must drop at least 7 in. below the shaft, and with a 9-in. shaft this means a ring diameter of 16 in. So the bearing must be more than 16 in. wide to allow the ring to be inclosed. To avoid this, a brass chain is used. It not only calls for a minimum width of bearing, but draws up the oil faster. As we learned today, it has its objections, for it wears out and breaks. A brass chain is used rather than a steel chain because it saves wear on the shaft. But I blame Kelly somewhat for the hot bearing. He should have noticed that it was getting warm and run the oil hose from our storage tank on it. It's one of the few times Kelly has been caught asleep at the switch."

"Chief, what about the splash system?" inquired Woods.

"The splash system," Egan rejoined, "is probably all right on an automobile engine, but you can never be certain that the oilways are open. It may sound fishy, but at one of our plants a shaft bearing burned, even though the crank case was properly filled with oil. Someone left a bunch of waste on the bearing cap to keep out dirt while taking out a piston. If there had been some kind of stream lubrication, the lack of oil would have been discovered. Again, if an emulsion of water and oil is used, water may get into the bearing, and you know that a little water soon destroys any oil film on a rotating shaft.

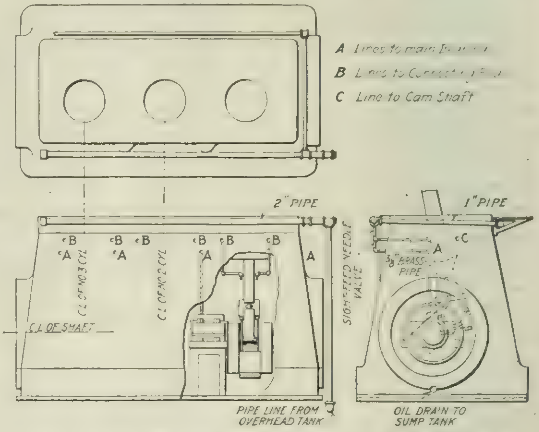


FIG. 1. ARRANGEMENT FOR STREAM LUBRICATION

"Furthermore, the splash system uses too much oil. We use two quarts of crank-case oil every two hours, or 6 gal. per day, on our 225-hp. engine, which means an average of 0.001 gal. per horsepower per hour. Compare this with one of our 500-hp. engines without splash lu-

At the next meeting the subjects of discussion will be fuel oils, filters and storage tanks

brication. Our records show 3.3 gal. of oil per day, and on a 20-hour run this equals 0.00033 gal. per horsepower per hour. Neither figure takes into account the oil for the air compressor, as that is about the same in the two engines."

"I notice that you throw away the oil each time we clean out a crank case," observed one of the men. "I should think the oil would be good to use."

"At first I thought the same," Egan confessed. "But it wasn't long before trouble with hot pistons and crankpins showed us our error. It's my experience that the crank case should be emptied every three months and the oil thrown away or else used on lineshafts, water-pump bearings and other places where a high-grade oil is not needed. The trouble with using this emulsified crank-case oil is that it contains water globules and so does not flow into oil grooves very readily."

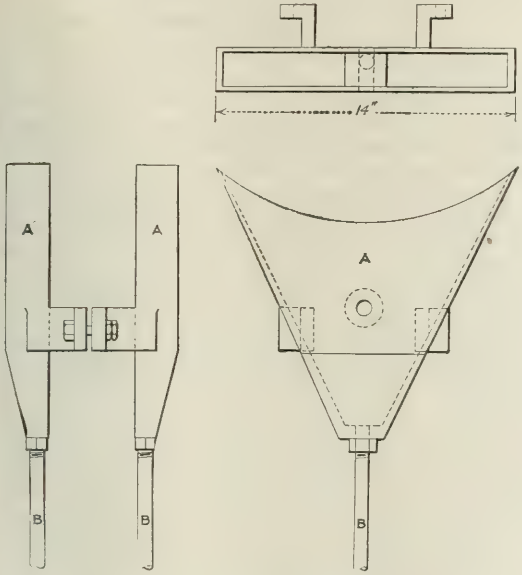


FIG. 2. DETAILS OF CONSTRUCTION OF OIL BOAT

"How much oil ought to be put in the crank case?" someone asked.

"Our practice is to put 8 gal. of oil in the pit under each crank and add enough water to bring the level about 2 in. above the bottom side of the crankpin when it is on bottom center. After the engine runs awhile, the emulsion of oil and water has a much higher level. You can get a good idea of the amount of oil in the case by putting your forefinger in the vent hole on the side door. After noting the feel of the oil as it strikes your finger, you should keep that degree of emulsion by adding water and oil at the necessary intervals. But this system is old-fashioned and it is profitable to change it to a system of stream lubrication.

"One of our plants that made such a change saved one-fourth of the oil bill and made the oiling more positive. Fig. 1 shows the arrangement. The oil was stored in an overhead tank and after going through the bearings, drained off to a filter in the basement, from which it flowed to a sump tank that was emptied once a day by a hand pump, the oil being discharged into the overhead tank again."

"I don't get the way the crankpin is oiled, chief," spoke up Kelly.

"We had aluminum oil boats or funnels, like those shown at *A*, Fig. 2, clamped together on opposite sides of the connecting-rod," said Egan. "The rod was tapped for two ⅜-in. capscrews that passed through the boats and kept them from moving, and ¼-in. brass pipes *B* led to the brasses, which were tapped to receive the pipes. The length of the boats was such that the oil was caught no matter what position the connecting-rod was in."

"Well, how did they oil the piston and pin?" Woods inquired.

"A groove *A*, Fig. 3, was cut in the side of the piston and from the bottom of the groove a diagonal hole was drilled through the side of the piston. Into the hole was screwed a pipe *B*, the end of which was directly over the oil hole *C* in the connecting-rod and brass. A wavy groove was cut in the piston face, as shown in Fig. 4. Then three other holes were drilled through the water jacket, bushed, and fitted with check valves. The oil was injected by a small plunger pump connected to the needle-valve bell crank. Every time the needle valve was opened, the little pump squirted a shot of oil into the piston-pin oiler and the cylinder oilers. This oil injected onto the piston flowed along the groove and lubricated the entire circumference. It was a crude device, but it was cheap and satisfactory."

"Couldn't we use a scheme like that on our No. 1 engine with those chain-oiling main bearings?" asked Kelly, who had had enough of chains.

"I'm planning to do that very thing," Egan replied. "It will be simple. All the oil cellars are now connected by a common drain pipe; so I plan to put in a line of nickel-plated pipe with outlets to all the bearings. I'll use an overhead tank and run the drain lines direct to the filter, which we'll put in a pit."

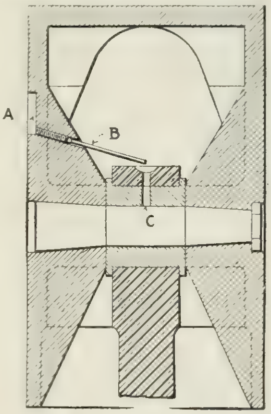


FIG. 3. METHOD OF LUBRICATING PISTON PIN

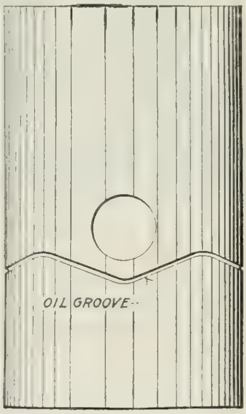


FIG. 4. LUBRICATION OF PISTON SURFACE

"Mr. Egan," Woods interrupted, "isn't a chain- or ring-oiled bearing O.K. if you use one of these mechanical oil pumps that lets a drop of oil run to the bearing ever so often?"

"I don't think so. Such a lubricator doesn't give enough oil to keep the temperature down, if a ring fails. So all it actually does is to furnish new oil to the oil cellar.

"Fig. 5 shows another oiling system. The mainshaft is drilled diagonally so that the pins may be oiled. The oil is handled by a rotary pump geared to the engine shaft. The oil line runs to the bottom of each bearing housing where it enters the bearing. Part of the oil enters the diagonal holes and thus oils the pins. The oil drips into the crank case, flows to the filter and oil cooler and then back to the pump.

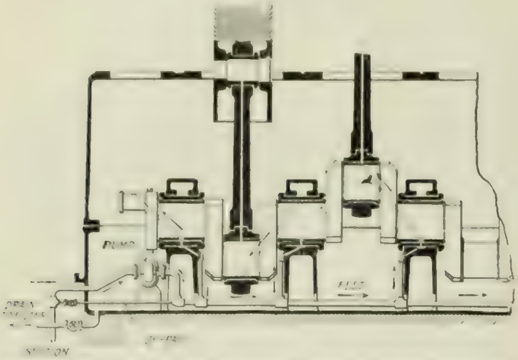


FIG. 5. DIAGRAM OF FORCED-LUBRICATION SYSTEM

"The advantage of this system is that the oil is forced into the bearing at the point of heaviest pressure. Consequently, lubrication is positive. There is no danger of the oil film being broken, as often happens with ring oilers. The pressure on the oil line as recommended by the builders is 15 lb., but we had better luck with 25 lb. The oil pressure is registered on a gage that furnishes an excellent way to learn if the bearings are getting oil. If the pressure runs up, it's plain that part of the pipe line is clogged or one of the bearings has got hot and stopped the port. If the pressure decreases, the filter may be dirty. A leak may have developed in the piping, the bypass may be leaking, or the oil may be escaping from the edge of the housing."

"What's the objection to this system?" asked Kelly, who always expected Egan to have some objection.

"The engine we use it on has water-cooled pistons, and the telescope tubes often leak, letting water get into the crank case and mix with the oil, causing hot bearings. So we put in a water separator made of a piece of 8-in. pipe with the drain pipe running into it, forming a trap, as shown in Fig. 6. I expect this to be drained of the accumulated water every day, but I have a hunch that you don't always do it."

The embarrassed laughter of the men was proof that the chief had guessed shrewdly.

"To lubricate a shaft bearing successfully by any oiling system, the oil must form a film and have low friction. Many oils that apparently are of proper viscosity and free from filler haven't enough cohesion to cover the shaft without breaking.

"Usually bearing oil receives less attention than cylinder oil. It's true that a cheaper oil can be used, but experience proves that bearing trouble is more prevalent than piston trouble.

"Now, let us consider piston lubrication. Almost all makes of engines use force-feed lubricators for oiling the cylinder walls. Many of these pumps are giving satisfactory service. Personally, I prefer the kind that is so geared that the oil is injected onto the piston surface when the piston is at the lower end of its stroke. In this way the oil is deposited on the piston when its temperature is fairly low. The piston with its film of oil lubricates the entire cylinder on the up stroke.

"It's practically impossible to get a suitable cylinder oil by specifying the flash point and viscosity. Personally, I believe in trying out an oil, and, if it works right, continue to use it. It must have enough body to seal the piston and rings and so prevent loss of compression, and it must burn without leaving a carbon deposit."

"Burn?" Kelly repeated wonderingly. "I always thought you wanted to use the oil to oil the piston and not to burn up."

"I've often been entertained by oil salesmen talking of the nonburning qualities of their oil," Egan replied dryly. "But the fact is that no oil on earth can be used in a cylinder of a Diesel engine without burning. On each power stroke the flame of the burning fuel charge absolutely consumes the film of lubricating oil on the cylinder walls."

"But, chief," Woods spoke up, "I've read that the average temperature in the cylinder isn't above 250 deg. F., and that isn't hot enough to burn lubricating oil."

"But we're dealing with maximum instead of average temperatures. I doubt that 250-deg. statement. Maybe the side of the cylinder walls in contact with the cooling water is that cool; but if you drilled a hole into the wall, you'd find the temperature running high enough to burn the oil. So we want a lubricating oil that will burn without leaving a carbon deposit. It must be strictly mineral, neutral and free from animal or vegetable oil, soap compound, mica, graphite or soapstone.

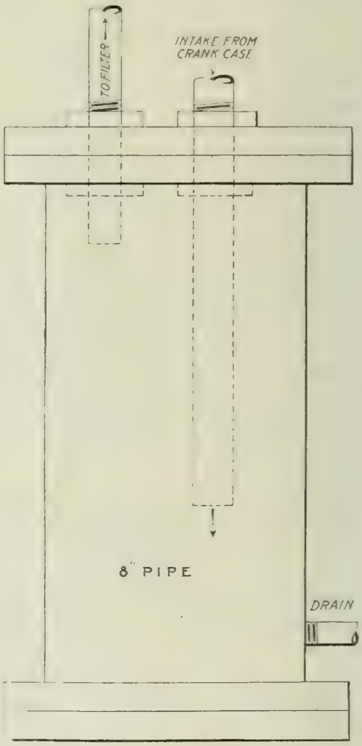


FIG. 6. HOME-MADE WATER SEPARATOR

"The chief trouble I find with you fellows is your habit of playing safe by using too much cylinder oil. The proper way is to reduce the drops per minute, gradually until you are feeding just enough to keep the piston lubricated. If you use too much, carbon is bound to form and the rings will gum in the grooves and cut the cylinder."

"How much oil ought we to feed. then?" Kelly wanted to know.

"You will find our lubricators all adjusted to give about 6 drops per minute to the cylinder and 15 drops per minute to the piston pin. As to camshafts and valves, it's best to use the same oil as with the pistons. One of our engines had grease cups on the valve-lever bearings, but we had to change to wick oil cups. The grease wouldn't run until the bearings warmed up, which was a thing we wanted to prevent. With the valves, it's best to use a little kerosene every day and oil about every four hours. The kerosene prevents carbon forming from the oil."

"Chief, you promised one night to say something about oiling gears."

"I'd almost forgotten that, Woods.' The trouble with helical gears is to get an oil that will maintain a film on the teeth. If the oil flows readily enough to form a film, it is likely to squeeze from between the teeth as they come in contact. And if it is viscous enough to keep from being thrown off by centrifugal force, it usually is too solid to form a film, acting more like a grease than an oil. The best way is to carry a high oil level in the gear case and have an oil cup that drops additional oil on the teeth where they come into contact."

Egan yawned, rose and stretched himself.

"Now, boys, let's hit the hay. It's hard days like this one that make me feel that soon the plant will need a new chief."

Brown Boiler-Room Signaling Pyrometer

Among other developments in boiler-room practice, engineers are giving attention to the regulation of firing by the temperature obtained in the furnace, boiler passes and uptake.

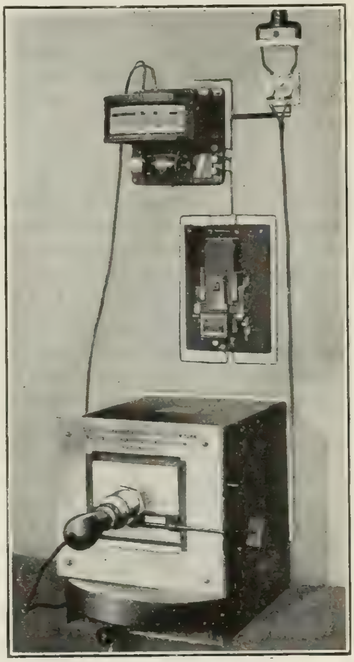
To indicate the boiler operation when the temperature is too high or too low, the Brown Instrument Co., Philadelphia, Penn., has developed a signaling pyrometer. Three lights are grouped for each furnace, a green light indicating that the temperature is too low, white that the proper temperature is being maintained, and red that the temperature is too high.

For instance, suppose the gases in the boiler uptake should run between 500 and 550 deg. F. with satisfactory firing conditions. If the temperature drops below 500 deg. the green light is automatically lighted, or if it exceeds 550 deg. it would show an excessive amount of heat passing up the chimney due to incompetent firing. The fireman having the group of three lights before him on the boiler, will endeavor to keep the white light burning by means of careful firing. The apparatus shown herewith operates automatically and is similar in construction to the ordinary indicating pyrometer.

A contact table adjustable throughout the whole scale range carries three contacts corresponding to the three lights, the central contact operating the white light, usually covering a space of 20 deg. on the scale, amounting to 10 deg. plus or minus the desired temperature. The pointer on the pyrometer is automatically depressed once a minute on the tungsten contacts.

An automatic three-position relay is operated by the closing of the contacts in the instrument. Assume that the furnace is started up and the low contact is closed, corresponding to the green light, and the relay completes the circuit through the green light. The contact in the instrument is closed only a few seconds to operate the relay, but the green light continues to burn until the temperature rises to the desired point, when the relay shifts, causing the white light to burn and extinguishing the green. The proper light continues to burn, although the contact in the instrument closes only for a few seconds once a minute.

It is frequently desirable to incorporate a hand-operated switch with the instrument so that the temperature of the thermocouple in a furnace may be automatically signaled and the temperature of other thermocouples may be read on the scale by some qualified official. This is easily handled.



SIGNALING PYROMETER

We will assume that the temperature of No. 1 thermocouple is to be signaled and the switch ordinarily remains on No. 1 point. It can be thrown by hand to Nos. 2, 3 or 4 points for instance, and when thrown the circuit through the lights is automatically cut off from the instrument, but the relay continues to maintain the light burning on No. 1 thermocouple until the other temperatures have been read and the switch returns by a spring to No. 1 position. Then if any change has taken place in the temperature while the other points were being read, the relay will automatically operate again.

By introducing an automatic motor or clock-driven switch in connection with a pyrometer, the temperature of practically any number of thermocouples can be automatically signaled by one instrument.

The cubic capacity of an 8-in. pipe line is about 328 bbl. of oil per mile. As the length of the principal pipe lines in the United States is over 30,000 miles, millions of barrels of oil are required simply to keep these lines in operation.

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Areas of Segments of Boiler Heads

By C. H. BERRY*

THE head of a boiler drum must be treated as a flat surface to be supported by either through or diagonal stays designed to carry the full load exerted against the head by the internal pressure. In the fire-tube boiler the tubes reduce the area to be stayed in two ways: First, each tube reduces the load to be supported by an amount equal to the internal pressure multiplied by the area of the tube hole in the boiler head; second, each tube is in itself an excellent stay, adequate to carry the load due to the pressure exerted against the adjacent portion of the head. Only in cases of exceptionally wide tube spacing are stays required among the tubes.

The shell of the boiler drum also acts as a stay and is able to take care of the pressure against an annular ring around the edge of the head, the width of this ring depending upon the thickness of the head, the pressure allowed and the radius to which the edge of the head is flanged. In most cases the tubes are spaced sufficiently near the shell of the boiler so that no stays are required between the tubes and the shell.

These successive reductions of the area to be stayed finally leave two sections of the head: One, the segment of a circle above the top row of tubes; the other, a segment of a circle, or sometimes a less regular figure, below the bottom rows of tubes. The areas of these portions of the head that require staying are determined according to rules laid down in the A. S. M. E. Boiler Code, in which formulas are given for obtaining the desired result, and it is the purpose of this article to discuss two charts by the use of which the desired results can be found without recourse to tedious numerical work.

The A. S. M. E. Boiler Code, edition of 1918, reads as follows:

214. AREAS OF HEADS TO BE STAYED. The area of a segment of a head to be stayed shall be the area inclosed by lines drawn 2 in. from the tubes and at a distance d from the shell as shown in Figs. 15 and 16. [Fig. 15 is given here as Fig. 1 and Fig. 16 as Fig. 2.] The value of d used may be the larger of the following values:

(1) d = the outer radius of the flange, not exceeding 8 times the thickness of the head.

(2) $d = \frac{5 \times T}{\sqrt{P}}$

where d = Unstayed distance from shell in inches;
T = Thickness of head in sixteenths of an inch;
P = Maximum allowable working pressure in pounds per square inch.

217. The net area to be stayed in a segment of a head may be determined by the following formula:

$$\frac{4(H-d-2)^2}{3}\sqrt{\frac{2(R-d)}{(H-d-2)}-0.608}$$
= *area to be stayed, sq. in.*

where
H = Distance from tubes to shell, inches;
d = Distance given by formula in Par. 214;
R = Radius of boiler head, inches.

218. When the portion of the head below the tubes in a horizontal return-tubular boiler is provided with a manhole opening, the flange of which is formed from the solid plate and turned inward to a depth of not less than three times the required thickness of the head, measured from the outside, the area to be stayed as indicated in Fig. 16 [Fig. 2 of this article] may be reduced by 100 sq.in. The surface around the manhole shall be supported by through stays with nuts inside and outside at the front head. The distance in the clear between the bodies of the braces, or of the inside braces where more than two are used, shall not be less than 10 in. at any point.

The two charts designated as Figs. 3 and 4 are intended to replace the two formulas quoted in Pars. 214 and 217. The chart in Fig. 3 gives the value of the allowance d, and that in Fig. 4 gives the area to be stayed. The first of these charts gives the value of the allowance d according to the formula, $d = \frac{5 \times T}{\sqrt{P}}$ as quoted from the A. S. M. E. rules. It will be noted that the rules state that d may be the larger of two values, either the outer radius of the flange or the value given by the formula. The rules further state that in taking d equal to the flange radius the value of d may not exceed 8 times the thickness of the head. On the other hand, there is no restriction on the value of d as given by the formula. This means simply that when the formula gives a value greater than 8 times the thickness of the head, d will be determined by the formula, regardless of the flange radius, and that when the formula gives smaller values, the flange radius must be taken into account. It is to be noted from the chart that the formula gives values greater than 8 times the head thickness only when the pressure is less than 100 lb. per sq.in. The value of the thickness T in the formula is taken in *sixteenths* of an inch, but in the chart, Fig. 3, this quantity is laid off on a scale of inches, divided into spaces representing thirty-seconds of an inch.

Before making use of the chart in Fig. 4, it is necessary to subtract the allowance d from the radius of the head (in inches), thus obtaining $(R - d)$, and also to subtract d from the distance H (in inches) between a line tangent to the top (or bottom) row of tubes and the boiler shell, thus obtaining $H - d$. With the two values thus obtained, the chart in Fig. 4 may be used to obtain the net area of the segment to be stayed, in square inches. An illustrative example, showing how the charts are used, is given on the page containing the charts.

If the area to be stayed is of the form shown in Fig. 2, it can be figured as the sum of the area of a segment, found with the aid of the charts, plus the area of a rectangle limited on one side by the chord of the segment and on the other sides by lines drawn 2 in. from the tubes.

Engineers and chemists have for many years decried the waste of burning raw bituminous coal. They have time and again shown that it is far more economical to break the coal up, by means of carbonization, into its constituent elements of solid carbon, gas, ammonia, oils and tars, thus releasing these several valuable products for use in their respective fields.

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EXPLANATION

1. Find the allowance **d**, which equals the larger of two values: either the outer Radius of the Flange, not to exceed 8 times the thickness of the Head, or the value given by the Chart, Fig. 3

2. From **R** subtract **d**
From **H** subtract **d**

3. Find from the Chart, Fig. 4, the net Area to be braced

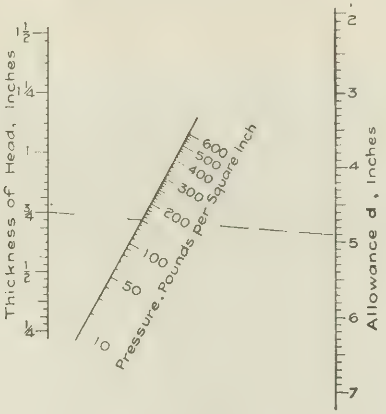


FIG. 3

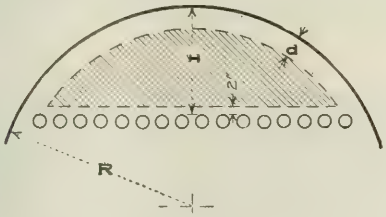


FIG. 1

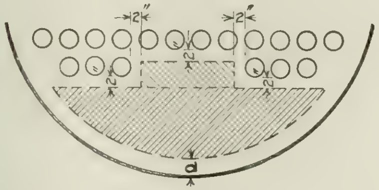


FIG. 2

EXAMPLE

Allowable Pressure = 150 lb.
Thickness of Head = ¾ in.
Radius of Head, **R** = 48 "
Height, **H** = 30 "
Allowance, **d** = 4.9 "
R - **d** = 43.1 "
H - **d** = 25.1 "
Area of Segment = 1256 sq. in.

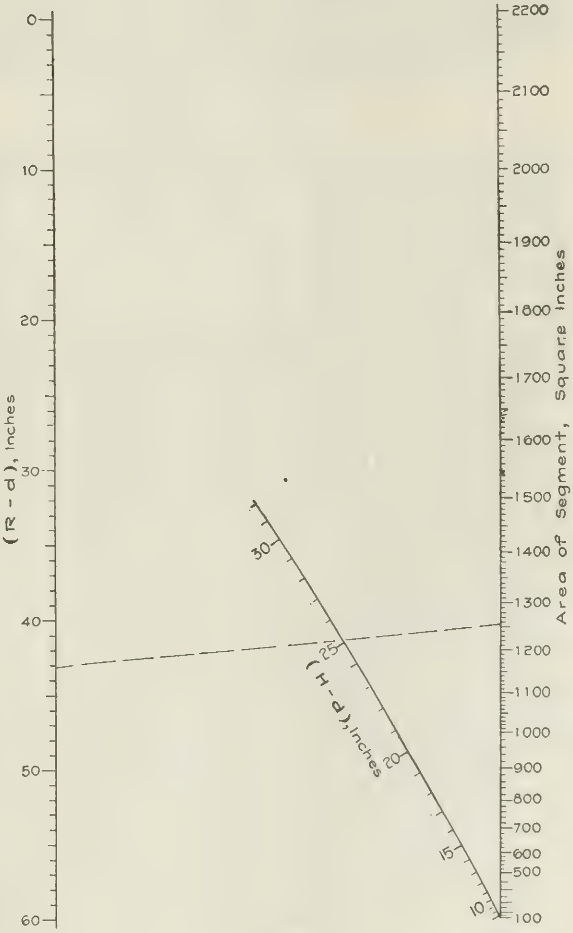


FIG. 4

C. H. BERRY, 10-30-1918

DIRECTIONS AND CHARTS FOR FINDING AREAS OF SEGMENTS OF BOILER HEADS

OPERATION at HOLTWOOD

By Charles H. Bromley

Holtwood (Near McCalls Ferry) is on the Susquehanna River about fifteen miles from Lancaster, Pennsylvania, and forty from Baltimore, Maryland. The station has hydraulic capacity of 118,500 horsepower in eight units with generators of 83,500 kilowatts rated capacity. It distributes at 70,000 volts.

Tells what causes may induce the governors of the hydraulic turbines to hunt and how to avoid or remove these causes. Great care is taken to insure adequate pressure of the fluid for the governor system. How operation of the turbine gates is continued should this pressure become reduced.

Hunting comes about through a number of causes, chief of which are oversensitiveness, too light dashpot oil, lost motion in the governor-operating mechanism, needle valve on the dashpot improperly adjusted, and permitting too free a movement of the piston in the dashpot. Heavy swings of load may induce the governor to hunt. After an interruption of service cross-currents between generators usually aggravate governor troubles. Serious surging in the tailrace, which may make and break the vacuum in the draft tube, will cause the governor to hunt. Electrical hunting of the generators due to disturbances on the system or to a bad shot in synchronizing will lead to hunting of the turbine governors. The electrical hunting must be stopped. Excessive lost motion in the restoring mechanism also may cause hunting. Hunting can usually be stopped by adjusting the dashpot needle valve, which should never be more than one-quarter turn open.

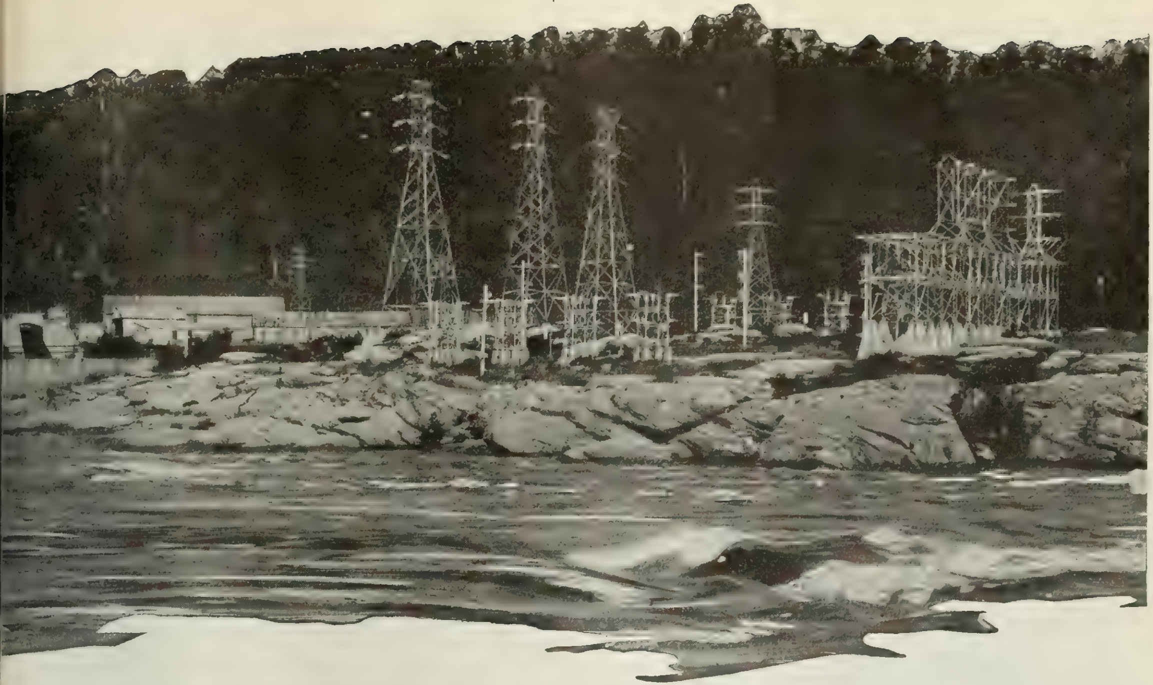
Holding the pilot-valve stem by the hand in a fixed position tends to stop hunting. The valve stem must not have side pressure exerted upon it, as this may cause injury to the valve.

In rare cases all governors will hunt at the same time. When this occurs, as many attendants as possible are placed at each governor to hold the valve stem by hand until the water in the forebay and tailrace stops surging. Widely swinging loads, as Sunday or holiday railway loads, induce surges easier than the combined industrial, railway and lighting load on weekdays.

Stripped Governor Gears—Careful observation is kept for hot governor bearings, for if these seize, the gears will be stripped, the governor made inoperative and the wheel gates will assume their balanced position, approximately 50 per cent. gate opening. During peak load the unit is cut out if this happens. The machine is changed over to hand control and continued in service until repairs can be made.

The damaged turbine is never cut out suddenly, as this would likely result in frequency disturbance.

The governor-regulating valve should always respond to movement of the pilot valve. When it does not, the regulating valve is stuck. Grit or scale caught in the valve, or wiping of the valve against the seats due to poor lubricating quality of the governor fluid, or a split valve ring, will cause the regulating valve to stick. When it does stick, it must be taken out and the cause removed. When a hissing sound comes from the regulating valve, it is an indication of excessive leakage. Should the restoring mechanism break owing to excessive friction in the pins or to severe surges, the gov-



ernor is cut out and the machine continued in operation by hand control.

Supply of Pressure Fluid for Governor System—There are two separate systems of pressure supply lines, return headers, sump tanks, pumps, etc.: One, the governor control; the other, the hand-control system. Fa-

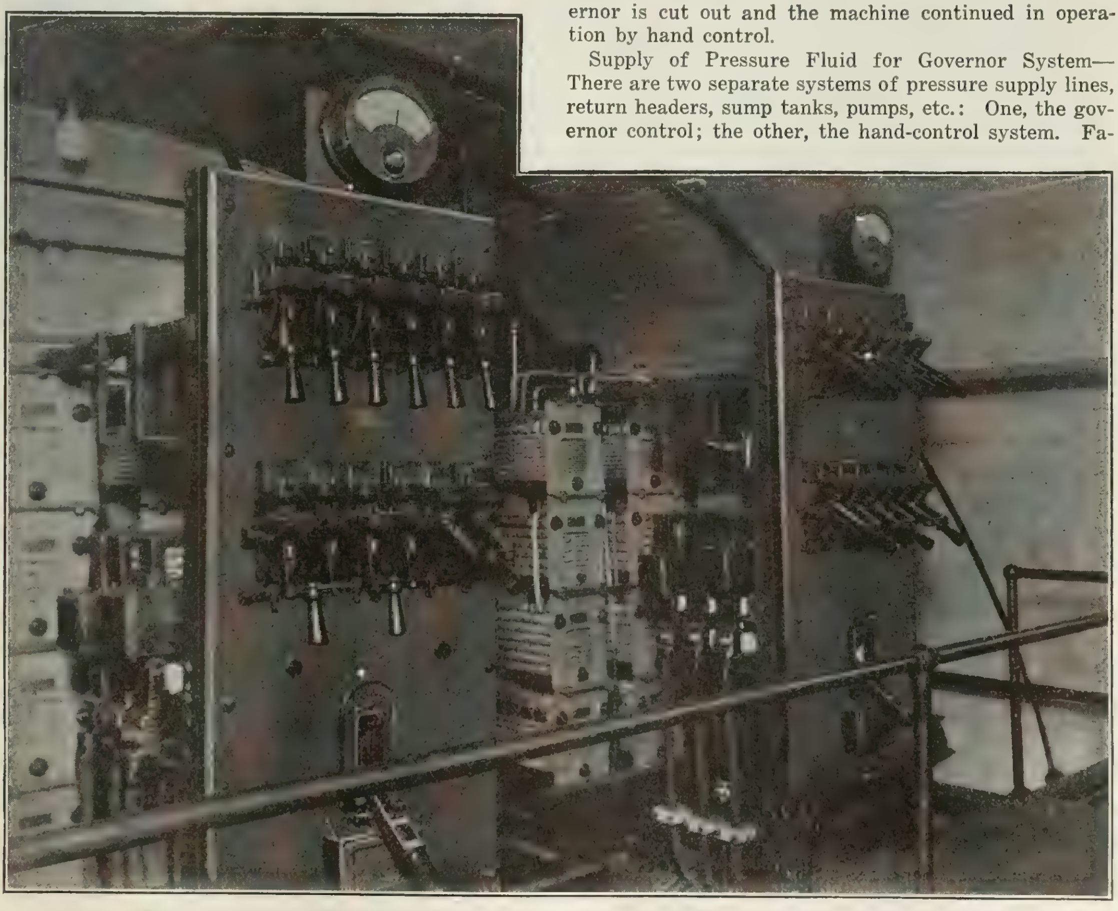


FIG. 1. SPEED-CONTROL PANELS FOR THE ALTERNATING-CURRENT MOTORS DRIVING GOVERNOR FLUID PRESSURE PUMPS

cilities for interconnection are provided, but normally the two systems are kept separated. There is a third gravity-pressure supply furnished by a concrete tank on the hill outside of the power house; this is used only in emergencies.

The governor-control system receives its pressure from four centrifugal pumps—two alternating-current-driven and two direct-current-driven. The hand control is supplied by a centrifugal direct-current-motor-driven pump and by a waterwheel-driven plunger pump. The motors of the alternating-current-driven governor pumps are arranged for variable speed, the adjustment of which is left to the care of the pumpman. This is accomplished by short-circuiting resistances connected in the slip-ring rotor circuit.

The direct-current driven pumps are started up automatically by contact-making pressure gages set for 240 lb. (see Fig. 3). This gage is mounted on the same panel with the solenoid-operated starting switches located near the pumps on the tunnel floor. The standard pressure gage shown on the illustration to the left of the panel is used in connection with the daily routine check made on the automatic starting feature of these pumps.

If the alternating-current power supply should fail temporarily, the alternating-current-driven pumps would slow down and both direct-current-driven pumps would come quickly into action. For a short time the pressure fluid stored in the accumulators, located on the thrust deck of each unit, could continue to operate the gate cylinders to the equivalent of four full strokes of the piston. The power supply to these motors is assured by the waterwheel-driven exciters and by a large emergency storage battery that would discharge automatically into the direct-current service connections in case the exciters should be disabled temporarily.

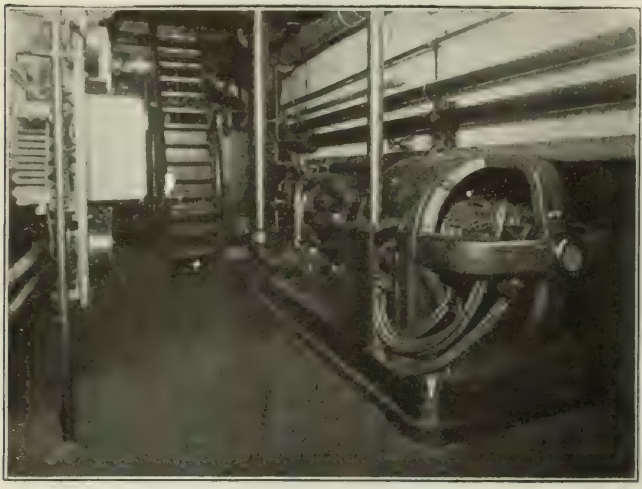


FIG. 2. DIRECT-CURRENT GOVERNOR PUMP SET

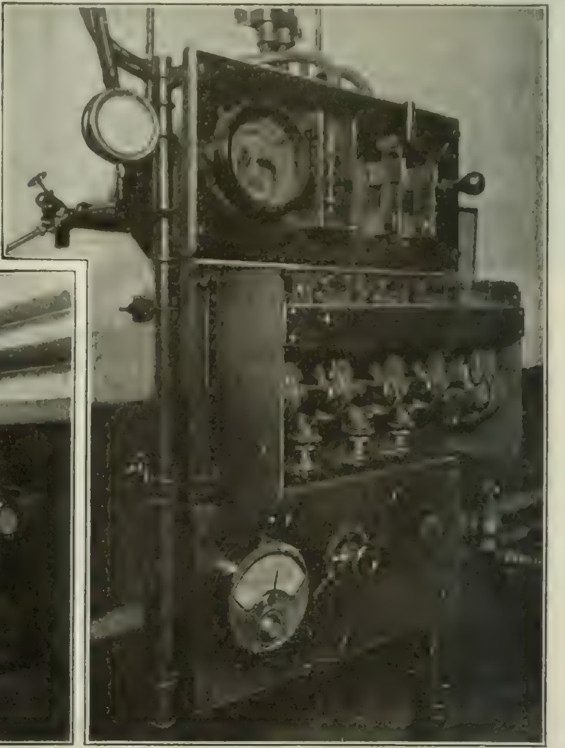


FIG. 3. AUTOMATIC STARTING PANEL FOR DIRECT-CURRENT DRIVEN GOVERNOR PUMPS ENERGIZED BY CONTACT-MAKING PRESSURE GAGE

High-Pressure Accumulator Air—This air is normally at 330 lb. per sq.in.; it is supplied by two air compressors (see Fig. 5). Should both compressors go out of service from any cause, the high-pressure air is obtained by filling one of the accumulator tanks with atmospheric air, or air at 100 lb. pressure, which usually is available, and building up the pressure by forcing water from the central pumping system into the accumulator. The pressure can thus be increased above the pressure in other accumulators, and it may be transferred to them through the pipe connections. The process must be repeated as many times as may be necessary to produce the required compression.

For the remote contingency that the entire pumping system should fail, the fluid may be completely drawn from the accumulator tanks and the compressed air in the tanks may escape through the governor valves. The first step, of course, is to restore the air pressure. The operator has his mind prepared for such a contingency and would resort to the air in the accumulator tanks of such units, which are not in service and which can be used to refill the tanks in which the pressure has been lost. Service may be more quickly restored by starting a unit that has been shut down, as its accumulator has the normal air pressure.

Sometimes, when the pressure is insufficient to move the wheel gates, closing the supply valves on units out of service will reduce leakage sufficiently to permit the necessary pressure to be built up.

Emergency Pumps on the Governor-Control System—There is a pump known at the plant as the Hill pump because it forces water to a tank on "the hill," which is near the station, the tank being at an elevation of 320 ft. from the pump. In the event of complete failure of the governor system and the hand-control system, "hill" pressure is admitted automatically through a check valve to the hand-control system, this water coming through the white, or filtered, water pipes connected to the hill pressure system.

To protect even against the contingency of loss of

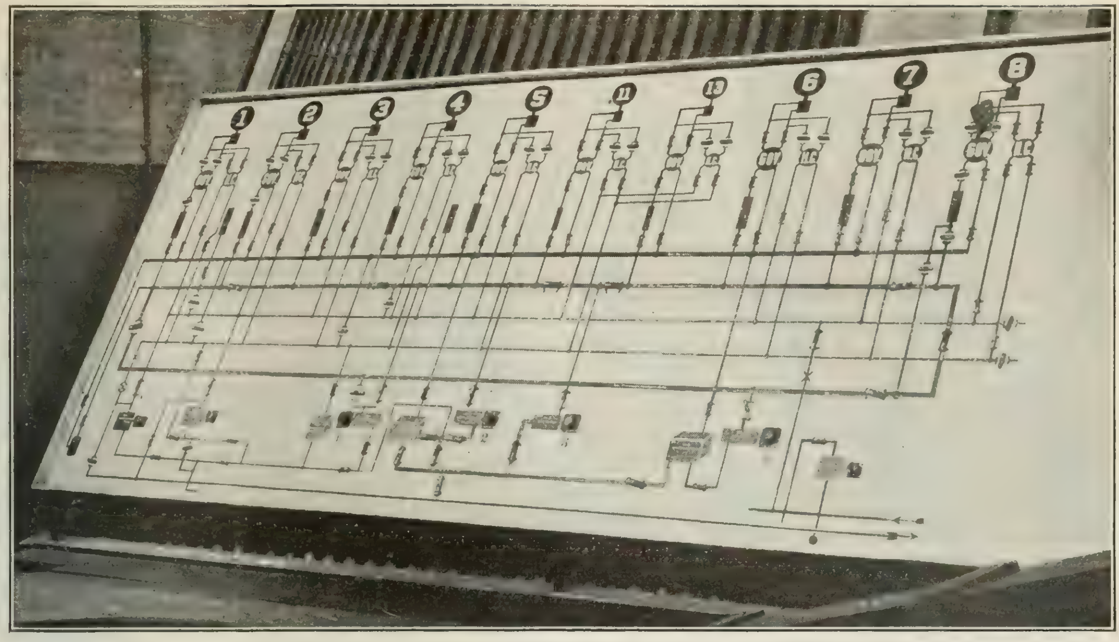
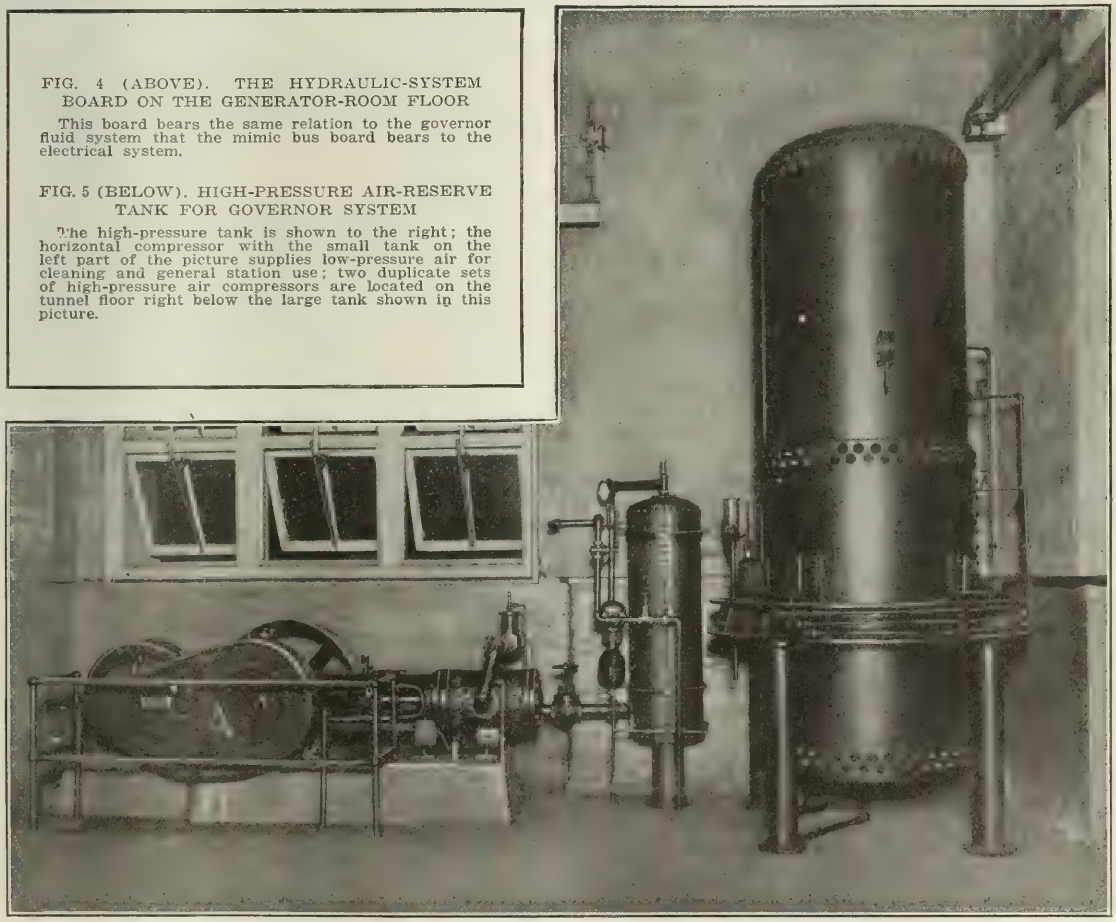


FIG. 4 (ABOVE). THE HYDRAULIC-SYSTEM BOARD ON THE GENERATOR-ROOM FLOOR

This board bears the same relation to the governor fluid system that the mimic bus board bears to the electrical system.

FIG. 5 (BELOW). HIGH-PRESSURE AIR-RESERVE TANK FOR GOVERNOR SYSTEM

The high-pressure tank is shown to the right; the horizontal compressor with the small tank on the left part of the picture supplies low-pressure air for cleaning and general station use; two duplicate sets of high-pressure air compressors are located on the tunnel floor right below the large tank shown in this picture.



full pressure, provision is made for quickly putting into service a small double acting hand pump, producing sufficient pressure to operate the exciter gates. A bucket of clean water is poured into the sump tank immediately beneath the operating cylinder for the gates of the exciter turbine. The balance pipe valves leading to the governor- and hand-control systems are then closed, the pump operated, and the valves leading from a four-way valve opened to the opening and closing side of the operating cylinder. To open the gates the four-way valve lever is moved to its extreme forward position; to close the gates the lever is moved in the opposite direction. As stated, this pump is for use only in a most serious emergency, therefore, the crews are drilled in its use so that when trouble arises, lack of experience by the operators will not cause unnecessary delay. So far this emergency pump had not yet been called for actual emergency work.

Sump Tanks—It is the practice at Holtwood to carry the fluid level higher than is customary in hydro-electric practice to safeguard against loss of fluid and against accident. Therefore the sump tanks occasionally overflow a little at times of severe governor surges.

Severe pumping disturbances tend to clog the screens on the pump sections. This is indicated by an increased vacuum shown by a gage on the suction side. The screens are immediately cleaned.

Causes of Loss of Governor Pressure—This may be due to loss of alternating-current power, loss of direct-current power, loss of both, loss of fluid or bursting of the fluid piping.

The piping is sectionalized and the hydraulic and electric operating attendants are familiar with all valves opened or closed at any particular time from the position of the indicators on the hydraulic mimic board. The telltale lamps on this hydraulic board (Fig. 4), visible from the benchboard gallery, will show at a glance which pumps have dropped out of service. The operator can observe, also, recording gages on the benchboard platform that show the governor- and hand-control pressures. The pumpman again gets his indication of the pressure section in the two systems by large-dial pressure gages mounted on a bracket in the center section of the tunnel, visible from both sides. These different indicating devices have been installed for the specific purpose of permitting a quick diagnosis of trouble in the governor-pressure system, so that attendants can restore normal condition with the least possible delay.

Don't Take Chances with the Synchronoscope

By F. Gillooly

Modern tendency in power-station design is to separate the control room from the generating equipment, at the same time increasing the number of the instruments used. Therefore the operator must become more familiar with his instruments, reading more from them than is printed on their dials, when operating the station from them alone.

With the large generating units now being used, the synchronoscope becomes a most important instrument, and it should be studied carefully by the operator. Only from long experience and close study results a thorough familiarity that enables one to correctly interpret the reading of instruments.

I once strolled in on an operator who was synchronizing a 1000-kv.-a. alternator. The plant was old; each of the engine-driven generators had its belted exciter and was controlled by hand-operated oil switches located in the basement, operated through a long, many-jointed rod mechanism. The operator was not sure of himself, as he frequently changed his mind when about to close the oil-switch. The synchronoscope was behaving queerly; it would jump from zero to 90 deg. slow, back to zero, then to 180 deg. fast and back to zero. A check on the conditions revealed the fact that while the bus voltage was 6000, the incoming machine's voltage was only 1000; the operator had forgotten to build up the exciter voltage.

Another operator on another system was not so fortunate. He was starting up a 9000-kv.-a. frequency changer, and after synchronizing the motor, he checked the generator voltage and plugged in on the synchronoscope. The pointer was right at synchronism and seemed as though it would tarry there a moment, which was rare luck. Seldom did a machine wait at exact synchronism for the switch to be closed. The oil switch was of the motor-operated type; the operator pushed the control button, and in went the switch.

For a moment he was not sure whether he had operated an oil switch or discharged a ton of dynamite. The oil switch tripped out with a flash and a roar; half a dozen coils in the armature were burned out, the lamination was melted, the field coils were damaged, the shields over the end of the stator coils were broken off and sucked into the machine by the magnetic field, then hurled in pieces against the wall and through the windows. Had the operator investigated why the synchronoscope's pointer did not move, he would have found that the generator's potential transformer fuses were out.

Another avoidable error was made by an operator when he tried to put in a 4000-kv.-a. turbine unit and could not get the synchronoscope to work. Investigation showed the synchronoscope selector-switch open, and after closing it, he hurried on with the synchronizing. As soon as the oil switch was closed it tripped; the load on the station dropped as the synchronous apparatus kicked out of step all over the system.

The dust quickly disappeared from the machine, which was let run at full speed and voltage. The operator found the machine's voltage even with that of the bus and the frequency the same, and decided that the oil switch must have been slow to close. He synchronized again with as disastrous results. On doing what he had neglected to do in the beginning—to check the synchronoscope—it was found at zero when the lamps were bright and at 180 deg. when the lamps were dark. The trouble was found to be caused by someone working on the synchronoscope during the day and not testing it afterward. These experiences indicate the necessity of checking the synchronoscope before paralleling alternators.

Under Section 91 of the New York Labor Law, supervision of steam boilers by the factory inspector applied only to boilers in factories. The Bewley Bill, just passed the legislature and been signed by the Governor, calls for the inspection of all boilers carrying pressures over 15 lb. per sq.in. in all classes and types of buildings.

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The Electrical Study Course—Current Division in a Three-Wire Generator

Explains in detail how the unbalanced current of a three-wire system divides among the armature windings of the three-wire generator.

In THE preceding lesson the path of the current in the neutral wire of an unbalanced three-wire system was traced through the inductances used with a three-wire generator. The next step is to investigate the path of the currents from all parts of the system through the armature winding. For this purpose a numerical example will be found convenient.

In Fig. 1 *G* is the armature of a three-wire generator supplying current to a three-wire system as shown. Suppose that the load *X* between *A* and *N* is composed of 100 lamps, each taking one ampere at 110 volts, and that the load *Y* between *N* and *B* is composed of 60 such lamps. Then the current in *A* would be 100 × 1 = 100 amperes and that in *B* 60 × 1 = 60 amperes. The neutral *N* would carry the difference, or 100 — 60 = 40 amperes. Since brush *a* is positive and brush *b* negative, the directions of the currents will be those indicated by the arrows. Upon reaching *g* the 40 amperes through *N* will have two paths to the armature, one through the inductance L_1 and the other through L_2 as explained in the preceding lesson. Having passed through L_1 and L_2, it continues through the armature to *a*. If the load *Y* were to be made larger than *X*, the current in *N* would flow from left to right instead of from right to left as shown, and the currents in the inductances would in that case flow in directions opposite those they previously had; namely, toward *g* instead of away from it. Just how the currents divide in the armature in either case will be made clearer by reference to Fig. 2.

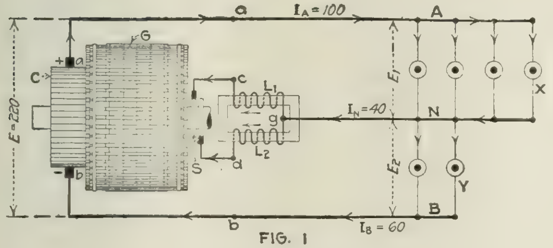


FIG. 1

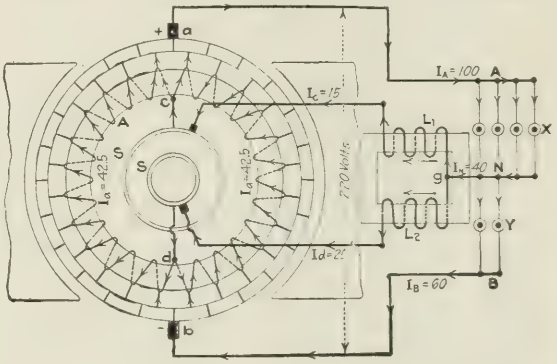


FIG. 3

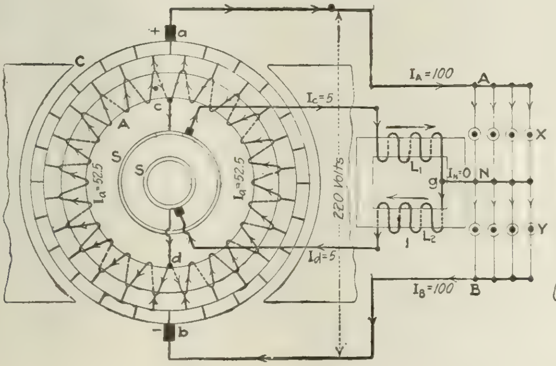


FIG. 2

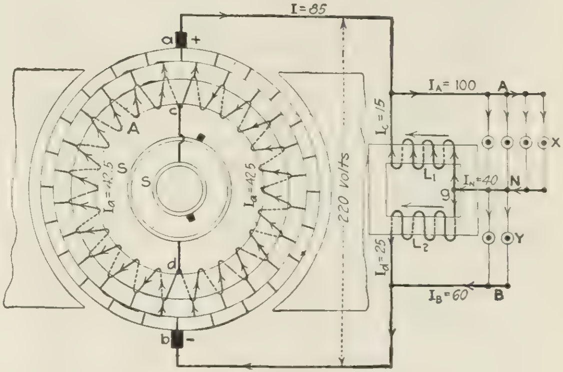


FIG. 4

FIGS. 1 TO 4. DIAGRAMS OF THREE-WIRE GENERATORS SHOWING DISTRIBUTION OF CURRENT

Let us first assume that the load is balanced, each side of the system carrying 100 amperes, under which conditions there will be no current in the neutral and consequently none in L_1 and L_2 other than the alternating current through them. Consider this current to be 5 amperes for the position shown in Fig. 2. This makes a total of 100 + 5 = 105 amperes going in at the negative point of the armature winding. The two halves of the generator's armature to the right and left of the brushes will each deliver half of the total load current, or 105 × 0.5 = 52.5 amperes. The direction of the current through the armature will be from the negative brush *b* to the positive one *a*, as shown by the arrowheads.

Suppose that the load is now unbalanced as in Fig. 3; that is, the load at *X* is 100 amperes and the load *Y* 60 amperes, causing a current of 40 amperes to flow in the neutral. It will be noticed that while the current leaving the brush *a* is 100 amperes, that entering the brush *b* is only 60 amperes, the difference being accounted for by the 40 amperes that flow from the neutral through the inductances and finally to the armature. The 60 amperes flowing from Y split at the brush b, half passing through each half of the armature winding to the right and left of the brushes a and b, as indicated.

In the last lesson it was shown how, if the exciting current in the inductances was 5 amperes, with the armature in the position in Fig. 3, then when 10 amperes was flowing in the neutral all the excitation for the inductances would be supplied by one inductance; how, when the armature was in the position shown in the figure, L_2 would be supplying all the ampere-turns, and when the current in the neutral increased above 10 amperes, the increase divided equally between L_1 and L_2. Therefore, in Fig. 3, 10 amperes of the 40 in the neutral will flow through L_2 to supply the ampere-turns and the remaining 30 will divide 15 through L_1 and 15 through L_2, making a total of 15 amperes in L_1 and 25 amperes in L_2. The 25 amperes flowing through L_2 enters the armature winding at d and divides, 12.5 amperes flowing through the winding to the right of brushes b and a and 12.5 amperes to the left, making a total of $30 + 12.5 = 42.5$ amperes flowing in each half of the armature, or a total of $42.5 + 42.5 = 85$ amperes. This, added to the 15 amperes delivered by L_1, makes a total of $85 + 15 = 100$ amperes, leaving the positive brush as indicated. The next thing is to investigate the power distribution in the system. The entire load on the generator is the sum of the loads X and Y and the excitation required by the inductances L_1 and L_2.

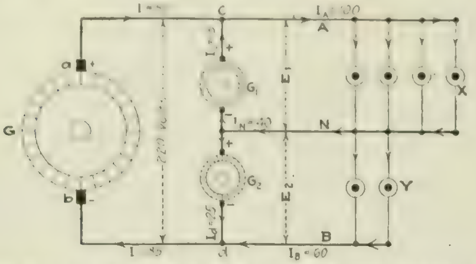


FIG. 5. BALANCER SET ON THREE-WIRE SYSTEM

Since the current in X is 100 amperes and the voltage across it is 110 volts, we have $X = 100 \times 110 = 11,000$ watts. Similarly, $Y = 60 \times 110 = 6600$ watts, and the watts taken by L_1 and L_2 at the instant shown in the 5×220 or $10 \times 110 = 1100$, making the total load that the generator has to supply equal to $11,000 + 6600 + 1100 = 18,700$ watts. The total current flowing in the armature is $42.5 + 42.5 = 85$ amperes; this value times the voltage gives the load supplied by the armature, equals $85 \times 220 = 18,700$ watts, which checks with the sum of the component loads on the external circuit.

In looking at Fig. 3, at first thought it might appear that the 15 amperes through L_1 should be considered in the current supplied by the armature; the fact is, however, that this current is not supplied from the armature, but is 220-volt power supplied to the system by the armature and is transformed into 110-volt power through the medium of the inductances. This will be more readily understood by referring to Fig. 4. At the instant shown in Fig. 3, if the inductances were disconnected from the brushes on the slip rings and connected across the line as in Fig. 4, the conditions would be identically alike except that the current flowing through L_1 would not pass through brush a. The current in the armature (60 amperes from load Y and 25 amperes through L_2), that is, $I = I_B + I_d = 60 + 25 = 85$ amperes. This gives the total power supplied by the generator equaling $EI = 220 \times 85 = 18,700$ watts, which check up against the lamp load of 17,600 watts, plus the power required by L_1 and L_2 at this instant, to excite them, of 5×220 or $10 \times 110 = 1100$ watts or a total of $17,600 + 1100 = 18,700$.

Comparing Figs. 3 and 4 with Fig. 5, the last representing a three-wire system obtained from a 220-volt generator G and a balancer set G_1 and G_2, it will be seen that all three are alike. The balancer set has been assumed to take 5 amperes at 220 volts to drive it without any load. As explained in previous lessons, the current division in this case would be as indicated in the figure, which is identical to that in a three-wire generator. In Fig. 5 the load on the generator is $W = 220 \times 85 = 18,700$ watts, and the system load is $X + Y = I_A E_1 + I_B E_2 = 100 \times 110 + 60 \times 110 = 17,600$ watts. To this must be added the 5 amperes at 220 or 10 amperes at 110 volts required to drive the balancer set, or 1100 watts, making a total load on this external system of $17,600 + 1100 = 18,700$ watts.

If the armature, Fig. 3, is turned through one-quarter revolution, it will be in the position shown in Fig. 6. As has been shown in previous lessons, no voltage exists across points c and d when the armature is in this position; therefore no exciting current will flow in the inductances L_1 and L_2, and the neutral current will divide equally between them; that is, 20 amperes will flow through L_1, entering the armature winding at c, halfway between brushes a and b, and 20 amperes through L_2, entering the right-hand half of armature at d, halfway between the brushes a and b. The 60 amperes in B enters the armature winding at the negative brush b and divides equally, 30 amperes going through each half of the winding. At points c and d these currents combine with the 20 amperes through L_1 and L_2, making a total current of $30 + 20 = 50$ amperes in the winding above points c and d, giving a distribution of the current as shown in the figure.

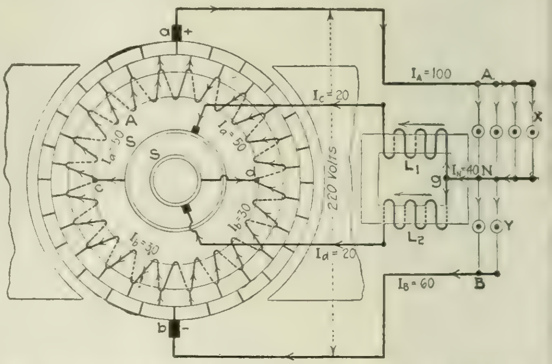


FIG. 6. THREE-WIRE GENERATOR. ARMATURE LOCATED ONE-QUARTER REVOLUTION FROM THAT IN FIG. 3

The load supplied by the generator at this instant is that at X and Y only, since the inductances do not take any power at the instant shown in Fig. 6. As has already been shown, the lamps at X and Y take $160 \times 110 = 17,600$ watts. The load on the armature may be looked at two ways; namely, 100 amperes at 110 volts, on the half of the winding above $c\ d$, plus 60 amperes at 110 volts on the half of the winding below $c\ d$, making a total of 160 amperes at 110 volts; or that the half of the armature above $c\ d$ is carrying 50 amperes at 220 volts, and the part below $c\ d$ 30 amperes at 220, making a total of 50 + 30 amperes at 220 volts. This gives 160×110, or $80 \times 220 = 17{,}600$ watts in either case, therefore the watts developed in the windings equal the watts supplied to the load, which is as it should be, of course neglecting the losses in the machine, which have not been considered in any of the discussions.

It will be seen from this discussion that although the current may have different values in different parts of the armature, it is balanced in the parts to the right and left of the brushes $a\ b$. The general statement can be made that the ampere-conductors (amperes times conductors) to the right and left of brushes $a\ b$ must always be equal, so as to make the available voltage in each half of the armature winding equal.

From the foregoing it is evident that the inductances differ from the balancer set in that the latter takes a certain amount of power from the generator continuously, as long as it is connected to the line, while the inductances take a maximum power when the armature is in the position shown in Figs. 2 and 3, and decreasing to zero when the armature is in the position shown in Fig 6.

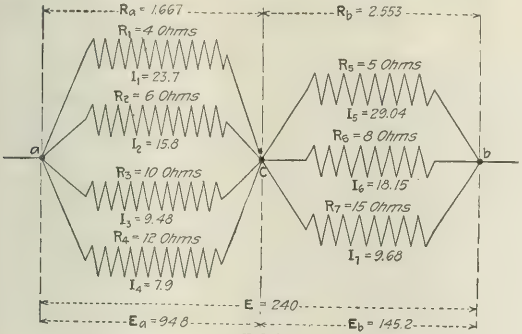


FIG. 7

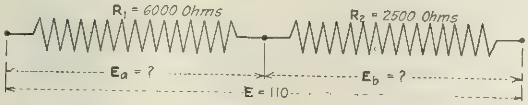


FIG. 8

FIGS. 7 AND 8. RESISTANCE CONNECTIONS

In the problem of the preceding lesson it was required to compute the value of the current flowing through each of seven resistances arranged as in Fig. 7, if a voltage of 240 volts were applied to them across $a\ b$. Since R_1, R_2, R_3 and R_4 are in parallel, their joint resistance is $R_a = \dfrac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}} = \dfrac{1}{\frac{1}{4}+\frac{1}{6}+\frac{1}{10}+\frac{1}{12}}$ = 1.667 ohms, and the joint resistance of R_5, R_6 and R_7 in parallel is $R_b = \dfrac{1}{\frac{1}{R_5}+\frac{1}{R_6}+\frac{1}{R_7}} = \dfrac{1}{\frac{1}{5}+\frac{1}{8}+\frac{1}{15}} = 2.553$ ohms.

The total resistance of the circuit is $R = R_a + R_b = 1.667 + 2.553 = 4.22$ ohms. Let I equal the total current, then we have $I = \dfrac{E}{R} = \dfrac{240}{4.22} = 56.87$ amperes. From this the following relations can be determined: $E_a = I \times R_a = 56.87 \times 1.667 = 94.8$ volts, and $E_b = I \times R_b = 56.87 \times 2.553 = 145.2$ volts. To check our calculation we may add E_a and E_b and see whether the result is 240 volts. Thus, $E_a + E_b = 94.8 + 145.2 = 240$ volts, as it should be. In each case the current would be equal to the voltage across the resistance divided by its resistance in ohms. Since R_1, R_2, R_3 and R_4 are all connected between a and c, they all have the same voltage across them; namely, $E_a = 94.8$ volts. Likewise the voltage across R_5, R_6 and R_7 is the voltage across cb or $E_b = 145.2$. Let the current through R_1 be represented by I_1, that through R_2 by I_2 and so on. We then have

$I_1 = \dfrac{E_a}{R_1} = \dfrac{94.8}{4} = 23.7$ amperes, and similarly $I_2 = \dfrac{E_a}{R_2} = \dfrac{94.8}{6} = 15.8$ amperes, $I_3 = \dfrac{E_a}{R_3} = \dfrac{94.8}{10} = 9.48$ amperes, $I_4 = \dfrac{E_a}{R_4} = \dfrac{94.8}{12} = 7.9$ amperes, $I_5 = \dfrac{E_b}{R_5} = \dfrac{145.2}{5} = 29.04$ amperes, $I_6 = \dfrac{E_b}{R_6} = \dfrac{145.2}{8} = 18.15$ amperes, and $I_7 = \dfrac{E_b}{R_7} = \dfrac{145.2}{15} = 9.68$ amperes. These results may be checked by adding I_1, I_2, I_3 and I_4, and comparing with the sum of I_5, I_6 and I_7. The two should be the same and should be equal to the total current I, or 56.87 amperes. Making the additions, we have, $23.7 + 15.8 + 9.48 + 7.9 = 56.88$ and $29.04 + 18.15 + 9.68 = 56.87$. The former is seen to be 0.01 ampere too great, but the slight difference is accounted for by the fact that the decimals in the computations were not carried out to very many places.

Two resistances R_1 and R_2 of 6000 ohms and 2500 ohms resistance respectively are connected in series across 110 volts as shown in Fig. 8. What is the voltage across each of them? If a voltmeter whose resistance is 14,372 ohms were to be connected across R_1, what voltage would it indicate? What voltage would it indicate if connected across R_2?

Representing Capacity of Equipment

In the late case of Merkle-Hines Machinery Co. vs. Gaynor, 170 Northwestern Reporter, 381, the Iowa Supreme Court laid down the following rules of law applicable to sales of power equipment where the salesman makes representations concerning the capacity of the same:

A statement that second-hand steam-turbine generators are "in first-class condition and will carry the same guaranty as a new machine, as neither of them have been run to exceed six months," amounts to a warranty of the condition of the equipment and not merely to the expression of such opinion, commonly known as "dealer's talk," as is not actionable, the buyer having had no opportunity to inspect the generators before delivery.

An undertaking on the part of a seller that equipment is "of the full capacity, efficiency, and other qualifications stated in the attached specifications," and that the seller "agrees to correct any defects which may develop within one year," is not a mere agreement to replace defective parts, but constitutes the basis of a damage claim on the representation proving to be false.

Put another service star on your pocketbook. Buy Victory Liberty Notes.

Belted Motors and Group Drives

By W. H. Wakeman

Some engineers advocate the use of a motor for each machine in the shop or factory, regardless of the size required, and others favor the group drive as the most convenient and efficient. In many cases it is possible that a combination of the two systems will give the best results. When several small machines are located in various parts of a shop, it becomes necessary to provide a motor for each, even if some of them are but one horsepower capacity, and small motors are less efficient than one large enough to drive them all. If machines can be placed close together and driven by a single motor, the first cost will be less and the expense of operation will be more satisfactory.

To illustrate this point, Fig. 1 shows a comparatively high-speed motor hung from the ceiling, and as the machines to be driven run at low speed, two belt-driven countershafts are used. The three machines are set in line and connected by a chain-and-sprocket drive. The first is driven by a belt running at an angle of 45 deg., which is the right position for good results.

When a score of motors were to be installed at my plant, I did not allow them to be hung from the ceiling, but all were set on the floor or on platforms hung from the ceiling or anchored to the brick wall. Those that are on the floor are in the cooler part of the room and are always convenient for care and adjustment. Those that are on platforms are not in the warmer part of the room, and it is not a difficult matter to reach them for cleaning and oiling.

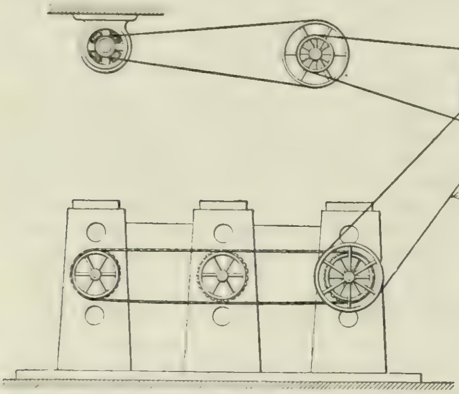


FIG. 1. MOTOR DRIVING TWO COUNTERSHAFTS

Referring to Fig. 1, if instead of the belt *A* there had been a chain-and-sprocket drive, a more positive drive would have been obtained. If a machine is designed to run at, say, 300 r.p.m., then that speed should be maintained. Should the belt slip on the driving pulley until the speed of the driven machine is reduced to 270, the output would be 10 per cent. less than it ought to be, although the expense of operation would remain the same as when full speed was maintained. Although a belt will give full speed to the driven machine if it is wide enough for the load, a chain-and-sprocket drive for light work and a silent-chain drive for heavy loads are always reliable in this respect; they are best adapted to low speeds.

Although Fig. 2 shows but one machine in operation, it represents a group drive. The motor is reversed and is bolted to the ceiling. On the countershaft is a large pulley *A* for reducing the speed. This countershaft is used to drive another machine, not shown. Another belt carries power to the second countershaft *B*. The pulley *C* is on a shaft that transmits power to another machine. Of course the load is light, as such an arrangement would not carry a heavy one, but it gives satisfaction. The pulley *C* revolves in the direction opposite to that of pulley *A* without the use of a crossed belt, which always creates friction.

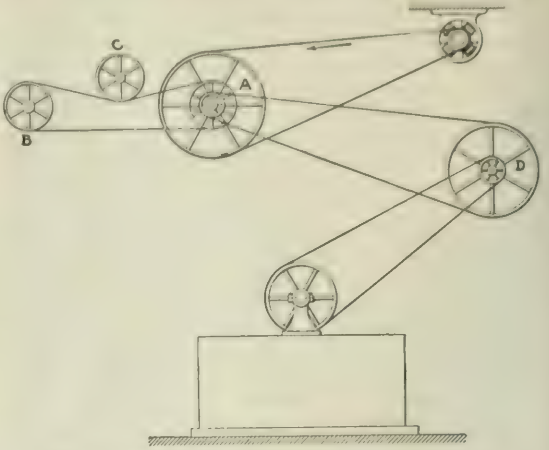


FIG. 2. MOTOR BELTED FOR GROUP DRIVE

These two belts operate to good advantage, because the lower side carries the load as indicated by the arrow. Power is transmitted from the first countershaft to the pulley *D*, but this belt cannot work to the best possible advantage, because the upper side carries the load, leaving the lower side to fall away from the pulleys and reduce the arc of contact when it really ought to be increased. Fig. 3 shows a motor belted to a countershaft from which is belted a pipe-threading machine. A vertical belt always works at a disadvantage, because none of the weight of the belt rests on the lower pulley, hence all tractive power must be derived from a tight belt. If a tight belt is frequently shifted from one step of a cone pulley to another, it soon becomes loose and will not carry the given load. If the ceiling of the room is high, this adds to the difficulty of changing the belts.

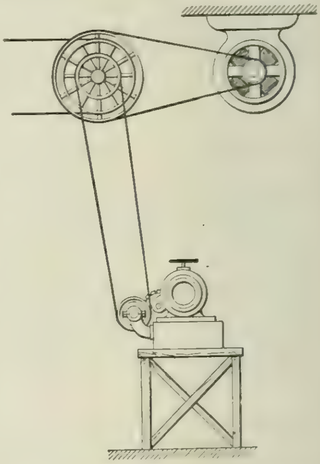


FIG. 3. VERTICAL BELT DRIVE

The lessons to be learned from the foregoing are that motors ought to be placed as the builders intended. Both motors and countershafts should be kept as low as possible. When possible, belts should be placed so that the lower side will carry the load and vertical belts avoided when conditions permit.

EDITORIALS

Wages and the Cost of Living

SOME enlightening figures upon the increased cost of living and the corresponding advance in wages in a number of industries, particularly the light and power group, are contained in the latest bulletin issued by the New York State Industrial Commission. The basis selected for comparison is June, 1914, a date representative of immediate pre-war conditions.

According to these statistics, the retail cost of foodstuffs has increased from that time to the present about seventy-five per cent., whereas the advance in wages in the light and power field during the same period has been sixty-eight per cent. This increase, while not nearly so great as that in certain other lines and trades, such as shipbuilding, the paper industry, etc., nevertheless compares favorably with that in the greater number of manufacturing plants, exclusive, of course, of those manufacturing war materials. Unfortunately, the figures do not discriminate between the classes of labor in the light and power industry, therefore it is impossible to form any deductions concerning the engineers and other operatives. Moreover, these figures represent averages only, and do not take into account injustices in certain individual cases, nor undue increases in others. However, making allowances for averages, it would appear that the increase in wages has not quite kept pace with the increase in cost of living, or at least in foodstuffs which may be taken as an index to the cost of living. While the difference is not so great as is generally supposed, it would appear that the average man in the light and power industry is economically somewhat worse off than he was five years ago. It is merely another example of the shrinking of the dollar.

While these figures are for New York State only, it may be assumed that they are fairly representative of the North Atlantic States, for, strange as it may seem, the figures for New York City did not differ materially from those of the entire state.

The Art of Synchronizing

THE many examples which could be cited of damage to apparatus and interruptions to service caused by carelessness in synchronizing or neglect in checking the synchronizing connections justify the injunction never to close the generator switch until the whole process has been checked up, by seeing the synchronoscope make one or more complete revolutions in a natural manner, and the synchronizing lamps checked against the synchronoscope to make certain that the latter is at the zero, or synchronizing, point when the lamps are dark. It is true that, except in the initial installation or during repairs or alterations, the likelihood of the synchronoscope connections becoming reversed is remote. This has happened, however, and the possibility always exists, particularly in plants where the operating force is large and work of some sort is continually being done on the switchboard apparatus. The man who considers himself capable in this line of work is due sooner or later to suffer a stern disillusionment unless he understands the principle of the entire synchronizing process and knows the layout and location of every circuit and every piece of apparatus. Operators of today have little excuse for poor synchronizing, considering the good regulation of the modern units, the positive action of the control apparatus and the stability of the load carried. They should consider the difficulties encountered by the operators of a few years ago, who had to synchronize many small, unstable units against a bus carrying a badly swinging load; when the coöperation between switchboard operator and engine room was scant, and the engineer could not always be persuaded to oblige by trying to hold the speed steady on the more or less ancient engine.

Much bad synchronizing is caused by operators not understanding their oil switches. Their principles and characteristics should be closely observed; for this purpose they should be frequently tried and inspected. The operator should know exactly the time lapse between the operating of the control switch and the closing of the oil switch. Motor-operated switches do this in less than one second; solenoid-operated switches in a slightly longer time. To the operator who is familiar with them, the indicating lamps tell the whole story of the remote-controlled oil switch's actions—the flicker of the lamp as the control is applied, the period when both lamps are lighted, then both dark, the positiveness of the second lamp's lighting—these things are indicative of the accuracy with which the switch is working.

An operator should be able to concentrate his mind so intently while synchronizing, that no distraction could lead him into making a false move. The habit of making false starts—nervously fingering the control switch, changing the mind when the switch is almost closed—betrays a lack of confidence and should be overcome. "Long chances" seldom pay, because usually some invisible factor is neglected. Quick thinking is good—when it is rational thinking. When the synchronoscope behaves queerly, taking a "pot shot" generally only makes an emergency situation worse, as pointed out in the article "Don't Take Chances With the Synchronoscope" on page 650 in this issue.

Increased Refrigerating Demands

THE exceptionally mild winter just past had its disadvantages as well as its advantages. It was welcome as a factor in keeping down the coal bill, but it is likely to contribute toward an increased bill the coming summer. The resulting scarcity of natural ice throughout a large section of the country will be felt by many communities and rural sections that have in the past depended in a large measure upon such supply. The result will be greatly increased demands for artificial ice, accompanied probably by an advance in price.

Aside from any price considerations, however, not only do the conditions point to increased demands for refrigerating equipment for both new plants and extensions to old ones, but existing equipment will be taxed to the limit. Therefore it now behooves the engineer to practice a little preparedness in getting his machines in first-class condition for the grueling service of the summer season.

In doing so he will undoubtedly run across many conditions and adopt measures that will be helpful to brother engineers confronted with like problems.

This is essentially an age of coöperation, of collective effort, whether applied to nations, to industry, or to labor, and in no field is this more true than in that of the operating engineer, who usually has to meet and solve his problems single-handed. In this connection, then, he is urged to make greater use of the discussion pages of *Power* as a medium for such an exchange of ideas.

Put the Victory Loan Over!

FAILURE was the last thing to enter the minds of our soldiers who braved the horrors and privations of the war. Indeed, it is doubtful whether they even gave place to the thought. Their grim determination to carry on until the grueling task was finished drove out every unworthy doubt.

They refused to be dismayed, for their courage and honor were at stake. They did not underestimate the magnitude of the resistance they would have to overcome, but their pride would not suffer it to check them. They felt that they had a sacred duty to perform and they did it.

Therein lies a lesson for subscribers to the Victory Liberty Loan.

The absorption of the $4,500,000,000 of notes offered is a gigantic financial undertaking, but it is no larger than others that have been carried out successfully. The size of the loan should not daunt us, therefore.

Moreover, the full subscription of this amount is an obligation laid upon us, and it cannot honorably be evaded. Pride in our own steadfastness of purpose and integrity of action should keep each of us from attempting to shift his share of the burden to other shoulders.

Early reports indicate that the Victory Loan is being received enthusiastically and that many localities subscribed their entire quotas before the drive opened.

However, well begun is only half done. Let us finish the other half speedily!

Covering Data Marking

THE omission of little things frequently leads to considerable inconvenience, and this is especially true in power-plant practice. Take, for instance, steam-line valves. Considerable trouble and expense is taken to protect the steam-pipe lines against condensation. When the work is finished, it is attractive as well as economical, and as a general thing all goes well for a time.

Eventually, however, parts of the valve begin to give out, and in order to determine the number of any particular valve, it is necessary to tear away the covering of the valve body, on which the number is generally placed. This mutilation of the pipe-line insulation is of frequent occurrence, and it could easily be avoided if manufacturers would either stamp or have cast on the valve's bonnet all necessary distinguishing marks. If this were done, such valves would find immediate favor with engineers, provided, of course, all other points of design were equal to other makes of similar valves.

Take for another example, the feed-water heater. In all well-regulated plants it is covered with an insulating material. In most instances the nameplate and all other markings are covered. If the engineer desires to order new parts from the manufacturer for any particular size of heater, he has no means of determining its size or any other data that will give the maker definite information as to its exact design or size. This is particularly true where more than one type of heater is made by the same manufacturer.

Why would it not be well for manufacturers of all kinds of power-plant apparatus to place key numbers in such positions that they will always be exposed to view regardless as to whether the device is covered or not?

The engineer who leaves his engine room to attend to work on the outside should remember that if an accident occurs while he is absent, he and he alone will be held responsible, and if he is operating with a license the chances are that it will be taken from him. Let someone else do the outside work.

Almost every engineer will instruct his firemen to keep the surface of the steam boilers free from soot, but for all that there are a good many firemen who do not realize that their work would be made easier if they would follow such instructions.

The engineer who yearns to hold the manager's job because it involves nothing but wearing good clothes, smoking fat cigars and toying with a paper knife is an unconscious Bolshevist.

Setting engine valves with the aid of a knife blade as a gage may have been illuminating years ago, but the question arises, What is the standard thickness of a knife blade?

The perpetual-motion crank is the Bolshevist of the mechanical world, for he firmly believes that he can produce unlimited comforts and necessities without personal exertion.

When it comes down to a fine point the modern power plant, if it is to be efficient, will be on a daily, weekly and monthly test. If not there is room for improvement.

It is essential to have indicating and recording instruments in the boiler plant, but before they are of any benefit the fireman must be educated in their use.

Bare and poorly insulated steam and hot-water piping is one of the most easily preventable causes of steam-plant losses. Why allow the losses to continue?

How many engineers know how much heat goes up the chimney, and if so, how the amount could be reduced? It seems simple, but how about it?

Correspondence

How to Do a Good Job Cutting Conduit

It is well-known that conduit must not be cut with pipe cutters because of the sharp edge or burr that is left on the inside. Unless this burr is filed or reamed out, it will damage the insulation of the wires when they are pulled through the conduit. For this reason a hacksaw is used on most conduit jobs. However, the method is slow and it is also difficult to make a straight cut on the larger sizes of conduit.

A method that I have found very satisfactory is to use the pipe cutters first, cutting as deep as possible without causing the burr, then finishing with a hacksaw, which will not take long and will assure a straight cut.

It is surprising how this speeds up a conduit job. The value of this method increases with the size of the conduit. L. W. Wyss.

Iron Mountain, Mich.

A Short-Circuit on Two Compound-Wound Generators

In his letter, "Generators Would Not Operate in Parallel," in the issue of Feb. 25, E. C. Parham describes a connection of two compound generators that will cause a short-circuit when they are connected in parallel.

In Fig. 1 of this article a connection is shown which is also unsatisfactory, but unlike that given by Mr. Parham, the equalizer connections are made correctly. The generator leads were run in conduit from the machines to the switchboard. When the machines were started for the first time, the following points were investigated and found correct: (1) Voltage across machine terminals were equal; (2) positive leads of machines to go to positive busbar and likewise negative leads to negative bus; (3) equalizer connection to equalizer bus and to the points on the generators where series field and armature are connected; (4) each machine was run separately under load and found to be overcompounded and the series-field shunts were adjusted for the correct value of compounding.

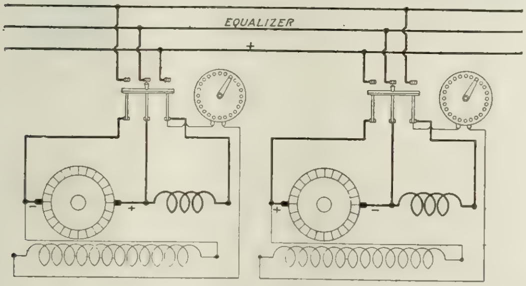


FIG. 1. WRONG CONNECTIONS FOR PARALLELING TWO COMPOUND GENERATORS

When the switches were closed to connect the machines in parallel, the circuit-breakers immediately opened. An examination of the connections shown in Fig. 1 will reveal that the armature of one generator is connected across the series field of the other, thereby causing a short-circuit.

It is evident that the four points mentioned will not fulfill all the necessary requirements. The fifth point is, armature terminals should go to the same busbar and likewise the series-field terminals, as in Fig. 2. When the machine leads run through conduit, care should be taken in testing them so that when the connections are made the requirements in point five shall be fulfilled.

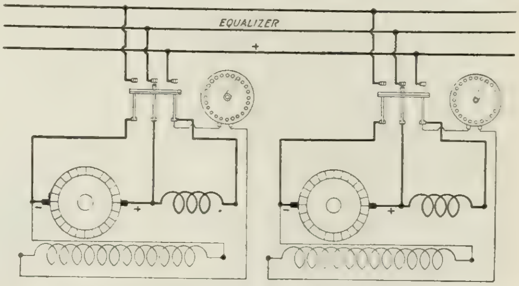


FIG. 2. CORRECT CONNECTIONS FOR PARALLELING TWO COMPOUND GENERATORS

J. O. Kammerman,

Associate Professor, Department of Electrical Engineering, University of Oklahoma.

Norman, Okla.

The Boiler Blowoff Cock Gives No Trouble

I have read considerable lately regarding boiler blowoff valves, and I would like to contribute a little of my experience. I have had 2-in. asbestos-packed blowoff cocks in use for six years without packing them and there are no signs of any leaks as yet; it is all in how they are handled. We carry 90 lb. pressure on the boilers, but we do not blow down at that pressure; that is done when the fires are banked, when the water is still in the boilers and when the pressure is low.

We blow into a tank that is quite a distance from the boiler. First the plug-cock is opened a little in order that the cold pipe leading from the blowoff valve to the tank will become gradually heated; then the cock is opened wide. In this way we get better results and the plug-cock will have the same wear all around. Always opening the cock halfway will in time cause a ridge to form along the plug and it will leak. We blow the boilers down every day.

I have never found it good policy to blow boilers down when under high pressure, as it is dangerous and fails to get the best results. Some blowoff valves are placed in restricted places, and if the blowoff pipe should give away while blowing down, the operator has no means of escaping injury. Patrick Molloy.

New York City.

Thermos-Bottle Principle Applied To Steam Cylinders

I notice in your Apr. 8 issue an article entitled "Thermos-Bottle Principle Applied to Steam Cylinders," from which it would appear that the University of Wisconsin some years ago made comparative tests with jacketed compound condensing engines with steam in the jackets and also with the jackets connected to condensers. The conclusion from these tests was that the vacuum in the jackets had not the slightest effect on the steam consumption.

The meaning of this is not perfectly clear. My experience has shown that the carrying of a vacuum in the jackets of a low-pressure cylinder effects a lower steam consumption than if this jacket were filled with air, but that the jacketing of the low-pressure cylinder with steam effects about the same economy as when vacuum is carried in the low-pressure jacket. It is, however, not sufficient to simply connect the jackets with the condenser, as then it will not be possible to extract the air out of them. The air can, however, be extracted if the jacket is connected with a small pipe directly to the air pump. To do this a small hole is drilled into the space between the suction and discharge valves of the air pump to which the jacket connection is attached with a small check valve opening toward the air pump.

In 1905 this question was tested out on an engine built by the Nordberg Manufacturing Co. for the Sperry Flour Mill Co. at its plant in Tacoma. This engine was of the tandem-compound type developing about 450 hp. It had a steam jacket on the high- and low-pressure cylinders, the jackets extending also over the cylinder heads. The engine was operated with 170 lb. pressure, and a very high degree of expansion was carried out. Oil was used as fuel, and the tests with this engine showed an oil consumption of 0.748 lb. of oil per indicated horsepower per hour. The fuel consumption was the same whether steam pressure or vacuum was carried in the low-pressure jackets, but increased if these jackets were allowed to fill with air. It seems as if the diminished internal condensation in the low-pressure cylinder is about offset by the radiation losses to the atmosphere from the heated cylinder walls when the low-pressure cylinder is jacketed with live steam. These radiation losses are eliminated when the jackets are under vacuum.

Bruno V. Nordberg,
President and Chief Engineer,
Milwaukee, Wis. Nordberg Manufacturing Co.

Keeping Explosion Doors Tight

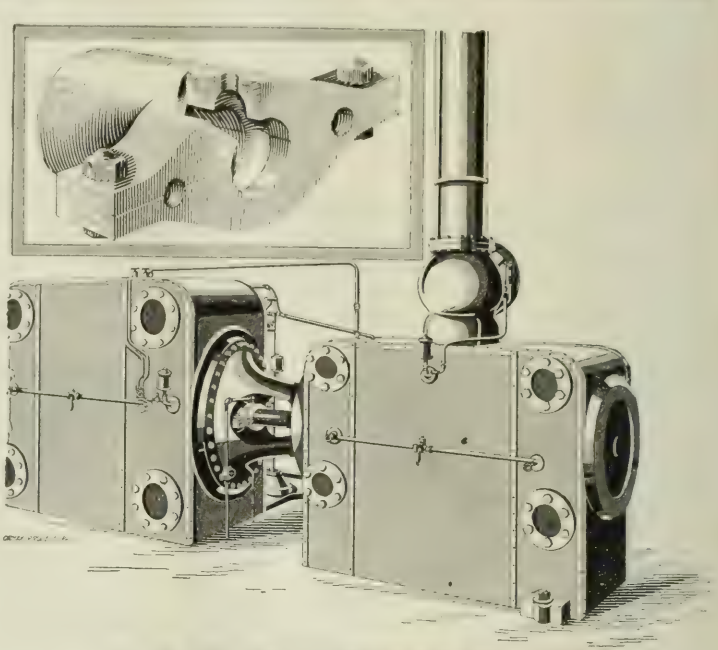
Explosion doors on boiler settings frequently give considerable trouble from air leaking in between the door and the frame. It is poor policy to go to the expense of applying a protective covering to the settings for the purpose of preventing the infiltration of air and then to allow the doors to pass large quantities directly into the furnace. After trying many ways of keeping these doors tight, I have at last found a very simple method which has solved the problem.

With doors hinged at the top, the frame extends from the wall several inches at the bottom, the door resting upon a packing ring laid into the frame, but it is difficult to keep this joint tight. I have seen many doors standing open at least one-half inch on the lower side. To remedy this I removed the ½-in. pin from the hinge and replaced it with a ⅜-in. one, which allowed the door to adjust itself to the packing ring. This is not possible when the door is held rigid by a tight-fitting hinge. A. C. McHugh.

Norwalk, Calif.

Hunting Vacuum Troubles

On one unit it was formerly possible to get but 16 in. of vacuum, but it was not long until I was getting between 24 and 25 in. with the cooling water going to a cooling tower. The condenser was of the barometric type. We have been told to test for air leaks with a candle. Now, for large leaks a lighted candle works all right, but I find the following to be a good way of testing out: When the condensing apparatus is shut down, put the condenser under from 5 to 10 lb. of water pressure and the leak will be easily found. Some small leaks are hard to detect with a candle, especially outdoors where the wind blows the flame in all directions. On the relief valve I tried a candle and could not discover any leak, but when I used a light oil on it the leak was easily found and one could hear the noise made as the oil was pulled in.



DESIGN AND APPLICATION OF THE SPECIAL GLAND

I also run a tandem-compound engine that pulled in air around the low-pressure metallic piston packing, thus causing a drop in the vacuum. This was remedied by putting on a steam seal in the form of a special gland, as shown in the illustration.

Hartford, Conn. F. W. Schneider.

The Mobile Boiler Explosion

With reference to the boiler explosion at Mobile, Ala., described in the Mar. 25 issue, it might be of interest to know that we previously had trouble with the stay-bolts in the Heine boiler. In January, 1917, we found five of these stay-bolts broken. These were immediately replaced. The following November another was replaced and in October, 1918, two more. As the result of the large number of stay-bolts being broken we took the matter up with the insurance company, and their inspector advised us that he could see no reason for the breakage and the only recommendation which he could make was that the bolts be replaced at the time any were found broken.

On the night of the explosion and at the time of the accident, boilers Nos. 1, 2 and 7 in the new power house were in use, and in the old power house the Heine boiler was being fired and likewise No. 8 Stirling. Stirling boilers No. 5 and 6 had been cleaned and banked. In the new boiler room the stoker on No. 3 boiler had been pulled out for several days, having repairs made on it.

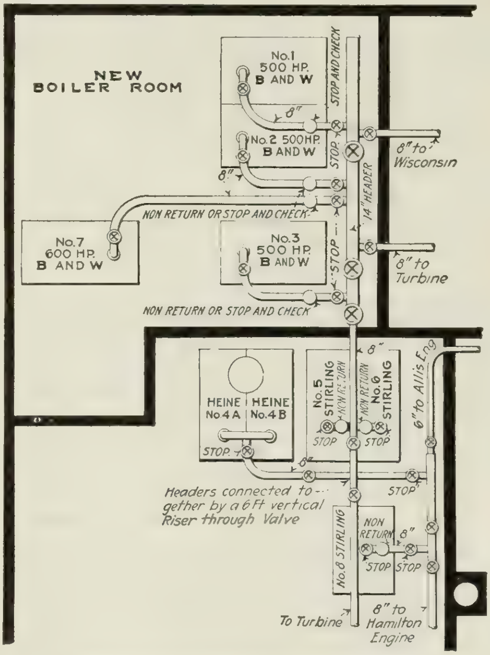
The chief fireman in the new boiler room stated that he was standing just in front of the alleyway between Nos. 2 and 3 boilers when he heard a cracking noise which he said sounded like the tearing of metal and at the same instant he saw the brick wall that divided the old boiler room from the new fall down. An instant later he was knocked down by flying bricks, and made his escape by crawling through a hole into the basement and thence through a basement window to the street. This statement, together with the trouble which we had experienced with the stay-bolt, indicates to me that it was the Heine boiler which exploded first. Examination of this boiler after the explosion showed that the rear water-leg broke along the top row of tubes, and a portion of this rear water-leg was found fastened to the rear drum and was bent very much out of shape so as to be in a position that would indicate that the water-leg was forced backward and very nearly horizontal. This water-leg gave way with such violence that it went through the 18-in. wall between the boiler room and hit a building column that supports both the east front of the boiler and a portion of the overhead coal bunkers. The force was so great that this column, which is made up of channels and boiler plate riveted, was bowed at a point half way between the floor and the top of the setting of boiler No. 3 so as to be very nearly twelve inches out of line. The buck-stay on the same side of the boiler was also bent about the same amount. The whole east brick wall of the boiler setting was forced in, with the result that all the brickwork on the boiler had to be torn down and the boiler had to be entirely rebricked. The insurance company thought it advisable that the boiler also be retubed; which was done. This boiler was set singly, and the west column supporting it was also bowed to nearly the same extent as the east one. The chain-grate stoker which had been rolled out was hit with such violence that all the frame castings, such as side girders and side frames, had to be replaced.

Inasmuch as an indentation in the head of No. 6 Stirling was found after the explosion and as the head itself was found practically at the same point where the mud drum of this boiler landed, it would seem that this head was knocked out and not blown out.

On the night of the accident there were thirteen men in the power house. The first assistant engineer, William Detlefsen, who has been an employee of the company for about eighteen years, was in the lavatory, and his statement was to the effect that he felt a mighty tremor. Immediately the lights went out and he was knocked down. He regained his footing and attempted to open the door, but was again violently knocked down and finally escaped through a window.

James Hudson, a switchboard operator, was standing near a division wall between the old and the new engine room. He stated that he heard no violent explosion and was quite unaware that anything had taken place until he realized that he had been knocked down and was unable to move. He was buried in the bricks from the fallen wall and sustained severe burns from hot water and steam.

Two oilers were in conversation at the cylinder end of the 1000-kw. Wisconsin engine. Both were knocked down, one being severely injured by flying bricks, whereas the other was absolutely unhurt.



BOILER PIPING AT MOBILE PLANT

In the new boiler room there were three men. The head fireman made his escape as already stated. Another man had his legs broken in three different places and received burns, and died within a few days at the hospital. The third man was so severely scalded that he died within a few hours after the accident. The man firing the Heine and the man firing No. 8 Stirling boiler in the old boiler room were both killed outright. Two firemen who had come off of duty at 8 p.m. were upstairs changing their clothes. These men were severely scalded and also died within a few days. In the basement were two ash pullers. One was unhurt, whereas the other received a few burns.

Attached is a sketch showing roughly the steam piping and location of the valves.

A. D. QUACKENBUSH,
General Superintendent, Mobile Electric Co.
Mobile, Ala.

Revision of Technical Courses

In your editorial of Feb. 25, in regard to revision of technical courses, you have touched on a timely subject, but I do not believe that you have covered every phase of the subject. It does not seem to me that more time should be put on this very important department of studies, but that the work should be given the engineer in a sympathetic manner and in such a way as will enable him to use mathematics as a tool in his subsequent work.

For a long time mathematics (one of the three fundamental engineering subjects) was given in the Science College of the University of Washington. For these professors mathematics is a most serious subject. In fact it is the only subject, and they think that the student must love it for its own self. Problems of the most academic sort become for the mathematics teacher a source of joy and delight. The following story is apropos: A mathematics teacher wrote a long differential equation on the board (two miles above the students' heads, figuratively speaking), stood back looking at it and said, "Isn't it pretty?"

We in the progressive engineering school of today now stand for mathematics to be so given as to enable the student to use it as a tool. He should have as complete and thorough training as it is possible to obtain in the high school, but in the college the subject must be given with the viewpoint that it must be usable and that the student should understand what he is doing and how he may make use of it. It is not usually understood that in the regular four-year engineering course, 2½ years are used in preparation for the professional work and the remaining 1½ years on subjects for which the student elected to enter college. The preliminary work is necessary, but it must be given in a sympathetic manner. One should remember that the engineering student is preparing himself for a certain kind of work in his future life. He has selected a certain branch of engineering. Therefore if the connection between the preliminary work and the later work is kept clear at all times, better results will be obtained.

As regards a review course in mathematics in the senior year, I believe this unnecessary. Applied mechanics, hydraulics, thermodynamics, machine design and numerous other professional subjects are the review of mathematics which engineers need, and this is what they get, and they see the bread-and-butter application of mathematics always before them. Therefore I stand for better presentation of mathematics; a method which will allow the engineer to apply the subject to his everyday problems. H. J. MACINTIRE.

Seattle, Wash.

The Cost of Banking Fires

After reading your editorial on the "Cost of Banking Fires" and seeing but one reply so far, I will describe the method I use in the plant of which I am in charge.

The manner of banking fires depends largely on the kind of coal, the time the fires are banked and the quickness with which the banks must be knocked down and the fires gotten under way. Some coals ignite easily and require only the hot furnace to ignite them, but with others a certain amount of fire must be left upon which to throw the green coal. Sometimes the bank has to be covered with ashes to keep the coal from burning out and running up the pressure, which is undesirable The plant under consideration consists of 72-in. x 16-ft. return-tubular boilers with 6 x 6-ft. hand-fired grates, both shaking and stationary. The fires are banked an average of twelve hours each day of the year.

Contrary to usual practice I have the fires banked on the front of the grates. The live coal is pushed well back to the bridge-wall and all ash raked out. The live coal is then pulled to the front and green coal is piled upon the live coals, completely covering them in some cases and only partly so at other times, depending on the coal. The bank can be placed well up on the deadplate or more on the grate, depending on the kind of coal. This gives a certain amount of control of the bank, so that the pressure will not run up and cause the safety valve to blow; at the same time the bank can be allowed to burn well through.

When it is time to get the fires going, it is only necessary to spread the bank and put on the draft, and in a few minutes the fire is good and hot, ready to make steam enough to pick up quite a load. And this ability to get under way quickly is important where boilers are banked in readiness to supply steam to fire pumps in case of a fire alarm or when considerable load must be picked up quickly. Some bank the fires just as they are when shutting the boilers down, by covering the fire with green coal and then cleaning when starting up, but I do not like that method.

The quantity of coal required to bank a fire under each boiler as I have described runs from 90 to 125 lb. As a rule 90 lb. is sufficient. Plants requiring as much as one-third of the total coal consumption for banking must operate but a small part of the time or else the fires must be kept burning slightly in order to supply leaks and thus hold up the pressure.

To obtain the best results from banked fires and keep stand-by losses down, it is necessary that steam leaks through valves and traps, also hot-water leaks, be kept as low as possible.

Where the steam lines are kept hot, nothing should be lost from the boilers but the condensation, and sometimes it is advisable to cut the boilers out entirely. It is surprising how much water a boiler will lose on account of a few steam leaks even when the fires are banked. CLIFFORD F. DANNER.

Lacombe, Alta., Canada.

Approximate Capacity of Pump

In the Feb. 4 issue of *Power*, page 183, is a formula for the approximate capacity of a pump, which is as follows:

$$g = \frac{D^2 \times 0.7854 \times L \times N}{231}$$

where

g = Gallons pumped per minute;
D = Diameter of plunger or piston in inches;
L = Length of stoker in inches;
N = Number of single strokes per minute.

This is then simplified to read

$$g = \frac{D^2 \times L \times N}{294.117}, \text{ usually written, } \frac{D^2LN}{294}$$

This can be simplified still further, making it easier to handle and as well to remember: $g = D^2LN\ 0.0034$.

Lakewood N. J. L. A. KEWOOD.

Inquiries of General Interest

Electrical Generator Running in a Vacuum—Would an electric generator operate if it were placed in a vacuum?

J. V. M.

Yes, as far as generating a voltage is concerned, and the windage losses would be practically zero. However, there being no means of ventilating the machine and a vacuum being practically a nonconductor of heat, it is doubtful if the machine could supply the power to excite its own field coils without overheating except for a very short period. If the field coils were separately excited, they would soon overheat for the reason mentioned.

Standard Temperatures of Melting Points—What are the temperatures of the melting points of various substances that may be used as standards?

W. N. A.

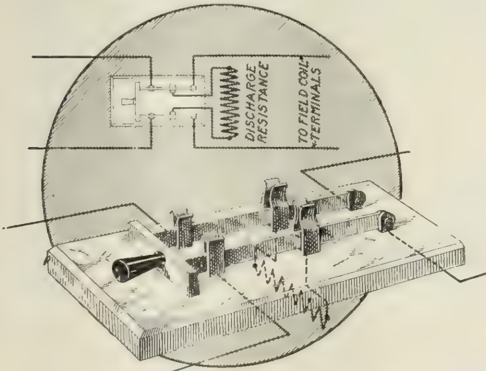
The melting points used by the Bureau of Standards as standard temperatures for the calibration of thermometers and pyrometers are as follows, expressed in degrees Fahrenheit:

Mercury	37.97	Antimony	1,166	Nickel	2,646
Tin	449.4	Aluminum	1,217.7	Iron	2,786
Cadmium	609.6	Silver	1,760.9	Palladium	2,820
Lead	621.3	Gold	1,945.5	Platinum	3,191
Zinc	786.9	Copper	1,981.4	Tungsten	6,152

Field Discharge Resistance—We have a 100-kv.-a. alternator and wish to build a field discharge resistance for it. How is the ohmic value of the resistance determined?

M. P.

The general practice for alternators is to make the ohmic value of the discharge resistance equal to the normal voltage of the exciter divided by three times the minimum field current, that is, the current flowing in the field windings, when all the rheostat resistance is cut into circuit. As an example assume the exciter's voltage to be 125 and when the rheostat is all cut into the alternator's field circuit it takes 5 amperes; then the ohmic value of the discharge resistance is $\frac{125}{3 \times 5} = 8\frac{1}{3}$ ohms. This resistance is usually made so as to carry the field current for thirty seconds without overheating. The circuits should be connected to a switch so designed that the field windings cannot be disconnected from the exciting circuit before it is connected to the discharge resistance as indicated in the figure.

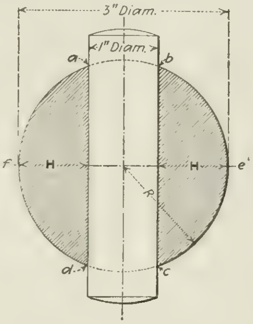


FIELD DISCHARGE SWITCH

For a synchronous motor the discharge resistance is calculated the same as for an alternator, but the resistance is made so as to carry the field current for two minutes. For a direct-current generator the ohmic resistance of the field discharge resistance is made equal to the normal voltage of the machine divided by the field current in amperes when all the rheostat resistance is in circuit; in other words, divided by the minimum field current at normal voltage.

Reduction in Tensile Strength of Piston Rod—What percentage of tensile strength of a piston rod is lost by drilling a 1-in. diameter pinhole through the center of the rod where it is 3 in. in diameter?

M. J.



Referring to the figure, the 1-in. diameter pinhole *abcd* drilled through a 3-in. diameter piston rod whose original cross-sectional area was equal to the area of circle *abecdf* would leave a total cross-sectional area of rod equal to the sum of areas of the equal segments *bec* and *dfa*. As 1 in + $2H = 3$ in., then H, the height of each circular segment, would be equal to 1 in. The area of a circular segment is given by the formula,

$$Area = \frac{4H^2}{3}\sqrt{\frac{2R}{H} - 0.608}$$

in which H is the height of segment and R the radius of the circles. As $H = 1$ in. and $R = 1\frac{1}{2}$ in., by substituting, the area of *bec* or *bfa* is found to be $\frac{4 \times 1}{3}\sqrt{\frac{2 \times 1\frac{1}{2}}{1} - 0.608}$ $= 2.06$ sq.in., or for both segments, $2.06 \times 2 = 4.12$ sq.in. As the original cross-section of the rod due to 3-in. diameter was $3 \times 3 \times 0.7854 = 7.07$ sq.in. and as drilling the hole would remove $7.07 - 4.12 = 2.95$ sq.in. of cross-sectional area, the loss of tensile strength would be $2.95 \times 100 \div 7.07 = 42$ per cent.

Thickness of Plates for Boiler Shell—What should be the thickness of steel plates of 55,000 lb. TS for a boiler shell 6 ft. 6 in. diameter to carry a working pressure of 125 lb. per sq.in. with a factor of safety of 5, if the longitudinal seams are triple-riveted butt-and-strap joints of 84 per cent. efficiency?

F. J. L.

The stress on one inch of length of the longitudinal joint of a cylindrical shell is equal to one-half of the product obtained by multiplying together the working pressure per square inch, the diameter and the factor of safety, or where P = working pressure, in pounds per sq.in., R = radius in inches, and FS = factor of safety, the required stress of 1 in. length of longitudinal joint $= \frac{1}{2} \times P \times 2R \times FS = P \times R \times FS$.

The resistance of 1 in. length of the longitudinal joint would be equal to the product obtained by multiplying together the ultimate tensile strength of the material, the thickness of plate and the efficiency of the joint, or where TS = ultimate tensile strength of plate in pounds per square inch of cross-section, t = thickness of plate in inches, and E = efficiency of the joint, the resistance of 1 in. length of joint $= TS \times t \times E$.

As the resistance must equal the stress,

$$TS \times t \times E = P \times R \times FS, \text{ or } t = \frac{P \times R \times FS}{TS \times E}$$

Calling $TS = 55{,}000$ lb., $E = 0.84$, $P = 125$ lb. per sq.in., $R = \frac{1}{2}$ of 6 ft. 6 in. $= 39$ in., $FS = 5$, then, by substitution, the last equation becomes

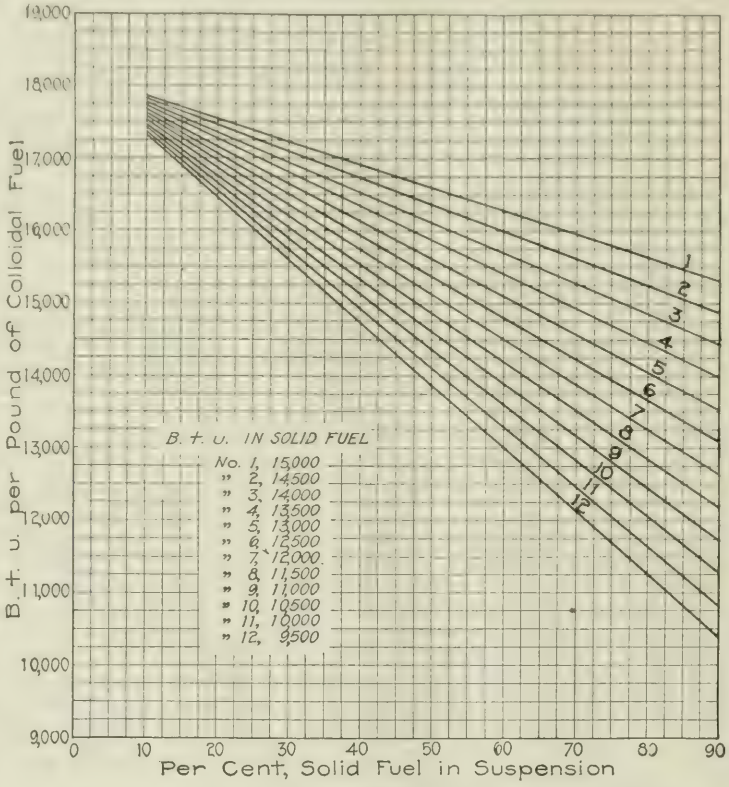
$$t = \frac{125 \times 39 \times 5}{55{,}000 \times 0.84} = 0.5276, \text{ or about } \frac{33}{64} \text{ inch.}$$

Tests of Colloidal Fuel

IN THE MAY 28, 1918, issue brief reference was made to tests that were being conducted of colloidal fuel at New Haven by the Submarine Defense Association with a view to conserving the fuel oil supply of the Navy. It is now possible to give further detailed information concerning these tests, which have been worked up under the direction of Lindon W. Bates, secretary of the association.

The trials were conducted on the patrol boat "Gem," a converted yacht with two 265-hp. oil-burning boilers of the Normand Express type, and extended over a period of several months.

The idea of an oil-coal combination is not new, but the difficulty heretofore has been due largely to the settling out of the heavier coal or tar product. In the present tests highly satisfactory results appear to have been obtained with a mixture consisting approximately of 69 per cent. fuel oil, 30 per cent. pulverized coal and 1 per cent. of a fixateur whose function is the stabilizing of the separate elements of different specific gravities so as to maintain a homogeneous product. Other mixtures also gave fairly good results.



COLLOIDAL FUEL COMPARED WITH COAL OF VARIOUS PRICES

The coal used in the tests averaged about 13,900 B.t.u. per lb., with an ash content of 11.4 per cent. Before mixing, it was ground so as to pass through a screen of 300-mesh, or 90,000 holes per square inch. Very little change was made in the oil storage tanks, the piping, preheating or burning mechanism, except that five instead of seven mechanical burners were used. At approximately 150 deg. F. and 150 lb. oil pressure the atomization of the colloidal fuel was as good as that of the fuel oil alone, and the B.t.u. consumption per indicated horsepower was about equal to that of the regular fuel oil. The heat value of the colloidal fuel, per unit of weight, due to the lower heat value of the coal, was somewhat less than that of the fuel oil alone—in the ratio of about 17,000 to 18,000; but owing to its greater specific gravity the heat value per unit of volume was slightly greater. Therefore, although the saving of oil for equal weight was 31.2 per cent., due to the lower heat value per pound of colloidal fuel compared to oil, about 10 per cent. more of the former by weight is needed to produce equal results. This means a net saving for equal volumes of about 27 per cent.

Table I shows comparative costs of oil fuel and colloidal fuel with coal at various prices. This, presumably, is exclusive of the cost of pulverizing the coal. The curves show the heat value of colloidal fuel with varying percentages of solid fuel in suspension with oil of 18,200 B.t.u. per pound.

TABLE I. COMPARATIVE COST OF OIL FUEL AND COLLOIDAL FUEL WITH COAL AT VARIOUS PRICES

Specific gravity of oil = 0 960
Specific gravity of coal = 1 40

Price of Straight Oil per Gal.	Price of Straight Oil per Bbl.	Cost of Colloidal Fuel				
		Coal at $1.00	Coal at $2.00	Coal at $3.00	Coal at $4.00	Coal at $5.00
1c.	$0.42	$0.65	$0 74	$0.82	$0.91	$0.99
2	.84	.92	1.01	1 10	1.18	1.27
3	1.26	1.20	1.28	1.37	1.45	1.54
4	1.68	1.47	1.56	1.64	1.73	1.81
5	2.10	1.74	1.83	1.91	2.00	2.09
6	2.52	2.02	2.10	2.18	2.27	2.36
7	2.94	2.29	2.38	2.46	2.54	2.63
8	3.36	2.56	2 65	2 74	2 82	2.91
9	3.78	2.84	2.92	3.01	3.09	3.18
10	4.20	3.11	3.20	3.28	3.36	3.45
11	4.62	3.38	3.47	3.55	3.64	3.72
12	5.04	3.65	3.74	3.83	3.91	4.00

Further tests indicated that it is possible to produce a stable liquid fuel from about 45 per cent. oil, 20 per cent. tar and 30 per cent. pulverized coal, together with a fixateur, thereby replacing over one-half of the oil. Also, by the greater use of higher sulphur oils or coals, the sulphur content of the mixed fuel can be reduced. The latest test with a mixture consisting of 30 per cent. Pocahontas coal, 8½ per cent. Texas Navy oil, 28.8 per cent. Mexican topped oil, 31.2 per cent. pressure still oil and 1½ per cent. fixateur, gave the following results as compared with those obtained on the same boiler with straight Mexican topped oil:

TABLE II. COMPARATIVE TESTS OF COLLOIDAL FUEL GRADE No. 13 AND MEXICAN OIL

	Colloidal No. 13	Mexican
Test No	6	1
Date	3/24/19	3/7/19
Length of test, hours	8	8
Quality of steam, per cent	97.2	97.3
Equivalent evaporation per hour	17,486	16,200
Fuel as fired, lb. per hour	1,286	1,159.5
Actual evaporation per pound fuel	11.6	12.06
Equivalent evaporation per pound fuel	13.6	13.97
Boiler horsepower developed	507	481.98
Per cent. rated capacity	126	119.6
B.t.u	17,200	18,482
Efficiency, per cent	76.8	7332

For several months the British admiralty has been at work raising vessels that were sunk by German submarines. So far, over four hundred merchant ships have been salvaged, although most of them had heretofore been counted a dead loss. Since the U-boats preferred to lie in wait for their victims near the coast, a large proportion of the sinkings took place in comparatively shallow water, which makes the salvaging much easier. The ship is raised by patching the hole in its side, which is done by divers, and then pumping out the hold. Work is done by huge submersible pumps lowered into the hold of the ship.

Crude Petroleum in the United States

The following comparative preliminary estimate by the United States Geological Survey, of the quantity of crude petroleum produced and marketed, consumed and held in storage in the United States in February and January, 1919, and February, 1918, is based on reports filed by about two hundred pipe-line, marketing and refining companies that receive crude oil directly from the productive fields east of the Rocky Mountains and upon statistics for California compiled from secondary sources because first-hand data could not be procured without undue delay. This statement, which does not take account of imports, indicates the general trend of conditions in the domestic crude-petroleum industry.

The quantity of crude petroleum run from wells and producers' field-storage tanks and delivered to pipe lines, marketing companies and consumers in the United States in February, 1919, amounted to approximately 26,511,000 bbl., a decrease of 3,358,000 bbl., or 13 per cent., compared with January, 1919, but an increase of 758,000 bbl., or about 3 per cent., compared with February, 1918. The average daily rate in February, 1919, was 946,822 bbl., a quantity less by 16,695 bbl., or nearly 2 per cent., than the average daily rate in the preceding month, though greater by 27,072 bbl., or 3 per cent., than that in the corresponding month of last year. As there are 31 days in January and only 28 in February, 1919, the monthly rates of production indicate a relative decline in the production of crude oil in February, 1919, compared with January, 1919, that is more apparent than real. The average daily rates of production, however, which in a comparison of this kind give an accurate index to the relative changes in movement of crude oil from the productive sources, show a decrease in February, 1919, compared with January, 1919, of only about 2 per cent., a condition due to the failure of the flush production in Central and North Texas to offset the decrease in the Cushing pool, Oklahoma, and in the Illinois field, which has been steadily declining in oil production for many years.

It is estimated that 27,159,000 bbl. of domestic crude petroleum was delivered in February, 1919, to refineries and other consumers of crude oil and used for the manufacture of petroleum products and for fuel. This quantity is less by 1,463,000 bbl., or about 5 per cent., than the quantity so delivered and consumed in January, 1919, and by 1,143,000 bbl., or only 4 per cent., less than the consumption in February, 1918. However, the average daily rate of consumption in February, 1919, which is more significant than the monthly rate, was 969,966 bbl., an increase of 46,676 bbl., or nearly 5 per cent., compared with the daily rate in January, 1919, though a decrease of 40,820 bbl., or 4 per cent., compared with the rate in February, 1918.

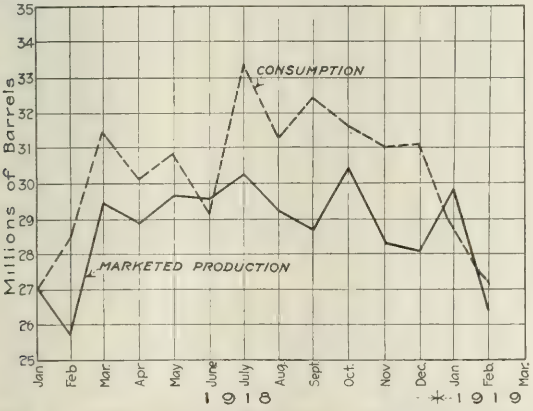
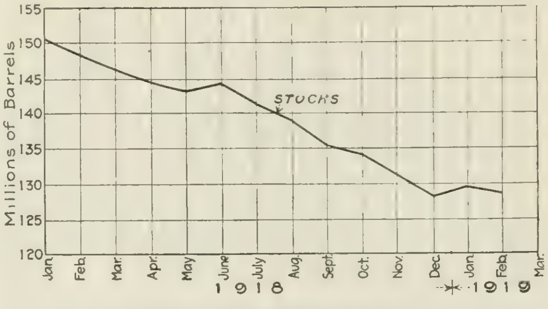


FIG. 1. COMPARATIVE MONTHLY PRODUCTION AND CONSUMPTION

The surface reserve of crude petroleum held on Feb. 28, 1919, by pipe-line and marketing companies and refineries that receive it directly from the wells was approximately 128,910,000 bbl., a decrease of 648,000 bbl., or 5 per cent., compared with the quantity on hand Jan. 31, 1919, and a decrease of 19,219,000 bbl., or 15 per cent., compared with the quantity in storage on Feb. 28, 1918.

Approximately 95 per cent. of the crude oil above ground in the United States in the months specified is included in the table, the remaining 5 per cent. representing unmarketed oil run by producers to private tanks and held as field storage.



MONTHLY STOCKS, 1918-1919

STOCKS OF CRUDE PETROLEUM AT END OF MONTH
(Barrels of 42 gal. each)

Class of Oil	February, 1919	January, 1919	Increase or Decrease, Feb.-Jan., 1919	February, 1918	Increase or Decrease, Feb., 1919-Feb., 1918
Appalachian....	3,969,000	3,777,000	+ 192,000	3,924,000	+ 45,000
Lima-Indiana..	1,229,000	1,181,000	+ 48,000	1,610,000	— 381,000
Illinois*.......	3,026,000	2,504,000	+ 522,000	3,331,000	— 305,000
Mid-Continent.......	78,107,000	80,252,000	—2,145,000	97,873,000	—19,771,000
Gulf Coast.....	8,866,000	8,528,000	+ 338,000	9,522,000	— 656,000
Rocky Mountain.........	1,042,000	1,016,000	+ 26,000	513,000	+ 529,000
California†....	32,671,000	32,300,000	+ 371,000	31,351,000	+ 1,320,000
Total.......	128,910,000	129,558,000	— 648,000	148,129,000	—19,219,000

* Includes Lima-Indiana oil stored in Illinois by the Illinois Pipe Line Co.

† Includes field, pipe line and refinery stocks of crude oil, residuum and unfinished refinery products.

The Making and the Destruction of Steel

Another overflow crowd attended a joint meeting of the mechanical engineering section of the Western Society of Engineers and the Chicago section of the American Society of Mechanical Engineers, held in the rooms of the former society on Apr. 21. Robert J. Young, manager of the Department of Safety and Relief, Illinois Steel Co., showed some interesting reels illustrating the triplex process of making steel. As an introduction the first reel showed mining methods in Minnesota, where three-fifths of the iron ore is obtained, loading boats at the dock and unloading at the mills. Subsequent pictures followed the process through the blast furnace, the bessemer converter and the openhearth furnace and the refinement of the metal in the electric furnace, of which the company recently installed three of 25 tons capacity. The series of reels presented were exceptionally good for steel-mill pictures and were highly appreciated by the audience.

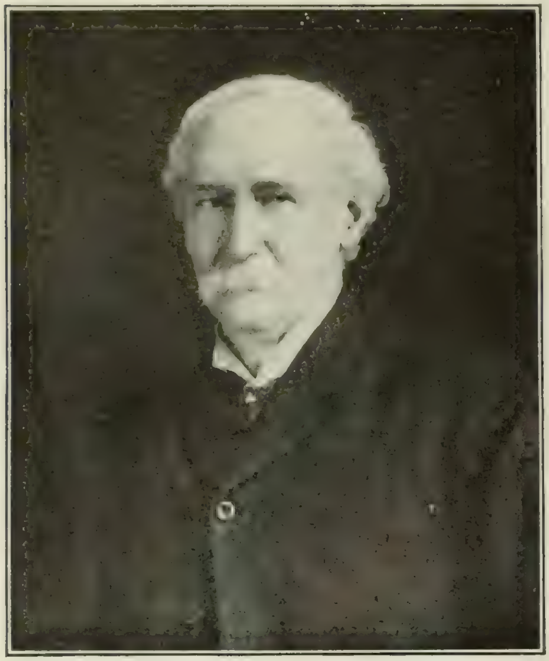
Prof. Herbert F. Moore, Department of Experimental Engineering, University of Illinois, talked on the "Fatigue of Metal." By means of successive photomicrographs of metals under stress the speaker showed the development of a fracture due to repeated loading. Numerous fine cracks first appeared and spread on the surface of the metal, and eventually at the point of greatest stress one or a series of these surface cracks developed into the fracture. The old theory of crystallization could no longer be accepted and failure from fatigue due to repeated stresses below the elastic limit was quite possible, notwithstanding the usual conception to the contrary. Also the impact test was not reliable. On numerous occasions it had been demonstrated that a polished surface added to the strength of the metal, as the fine surface cracks did not develop so readily.

Prof. Charles B. Richards

Charles B. Richards, Emeritus Professor of Mechanical Engineering at Yale, died at his residence, 227 Edwards St., New Haven, Conn., on Apr. 20, in his 86th year.

Professor Richards was born in Brooklyn, N. Y., Dec. 23, 1833, and was educated in private schools in that city. In his early days he moved to Hartford, Conn., and upon his removal from there to New York, came in contact with the late Charles T. Porter, by whom he was employed to assist in the preparation of drawings for a machine for drilling the arms and balls for his governor.

He later established himself as a designer of machinery and in 1861 was commissioned by Mr. Porter to design a steam-engine indicator that would overcome the faults of the instruments then in use, which were only for use on engines of slow speed. After repeated attempts, young Richards became discouraged, but goaded by Porter's insistence that he must have a high-speed indicator, renewed his efforts and the celebrated Richards Indicator was the result. When asked to patent the indicator, Richards refused, saying: "If I patent everything I think of, I shall soon be in the poorhouse." He finally agreed to sell his right in the invention to Porter for one hundred dollars, Porter to patent it and to employ him to obtain the patent. For the achievement of inventing the indicator he was made a Chevalier of the Legion of Honor of France.



CHARLES B. RICHARDS

Fon many years he was consulting engineer and assistant superintendent of Colt's Patent Fire Arms Co., Hartford, Conn., and while there designed and superintended the building of the two pairs of Porter-Allen engines which are still furnishing power to the older part of that establishment. The beds for these engines were cast in the foundry of one of the old engine builders in Hartford, who called on General Franklin, the general manager of Colt's Armory, to warn him that if Richards was permitted to put these engines in the second story of the building and run them at 100 r.p.m., disaster would be certain. The engines were started in 1867 and have been running almost continuously since that time.

Professor Richards was superintendent of the Southwark Foundry and Machine Co., Philadelphia, Penn., from 1880 to 1884, and was called from there to take the chair of mechanical engineering at Yale. He served as professor in that branch until 1909, since which time he has been professor emeritus.

He was United States Commissioner to the Paris Exposition of 1889 and has been consulting engineer for many public buildings, notably the State Capitol at Hartford. He was a member of the Société Industrielle de Mulhouse, a fellow of the American Academy of Arts and Sciences and a member of the American Society of Mechanical Engineers, being present at the meeting for organizing the last-named society on Apr. 7, 1880.

Professor Richards was married in 1858 to Miss Agnes Edwards Goodwin, of Hartford, Conn., who with four daughters and one son survives him.

Principles of Combustion in the Steam Boiler Furnace

"Principles of Combustion in the Steam Boiler Furnace" is the title of a new work by Arthur D. Pratt, of the Babcock & Wilcox Co., which publishes the book. As assistant to Dr. D. S. Jacobus, that company's advisory engineer, Mr. Pratt devotes much of his time to combustion and heat-transmission problems. The book, therefore, embodies much of the company's practice.

Instead of the usual review it is believed that readers of *Power* would like a more comprehensive "view" of this excellent book. It is in thirteen sections, dealing with the chemistry of combustion, density, weight and volume of gases, heat of combustion, specific heat, temperatures developed in combustion, air and combustion, combustion formulas, combustion loss, smoke, general conclusions.

Section XII deals with the computation of combustion data relative to coal, wood, oil, natural gas, byproduct coke-oven gas and blast-furnace gas. Section XIII treats of the heat balance for solid, liquid and gaseous fuels. These two sections are particularly valuable.

The following table is from page 10.

TABLE I. ELEMENTS AND COMPOUNDS ENCOUNTERED IN COMBUSTION

Substance	Molecular Symbol	Atomic Weight Accurate	Atomic Weight Approx.	Molecular Weight Accurate	Molecular Weight Approx.
Carbon	C*	12 005	12	†	..
Hydrogen	H_2	1.008	1	2.015	2
Oxygen	O_2	16 00	16	32.00	32
Sulphur	S_2	32.07	32	64 14	64
Nitrogen ‡	N_2	14 01	14	28.02	28
Carbon monoxide	CO	...	....	28.01	28
Carbon dioxide	CO_2		. .	44.01	44
Methane	CH_4		.	16.03	16
Acetylene	C_2H_2	...		26.03	26
Ethylene	C_2H_4			28.03	28
Ethane	C_2H_6			30.05	30
Sulphur dioxide	SO_2			64.07	64
Hydrogen sulphide	H_2S			34. 8	34
Water vapor	H_2O		.	18 02	18
Air	......	... ..	... .	28 94	29

* Atomic symbol. † The molecular weight of C has not been definitely determined. Carbon exists in a number of forms, each of which probably has its own molecular weight. The latest investigations indicate that a molecule of carbon in any form consists of at least 12 atoms. ‡ Atmospheric nitrogen as distinguished from chemically pure nitrogen, which has an atomic weight of less than 14.01.

Table II is from page 18, and designated Table 5.

TABLE II. DENSITY, WEIGHT AND VOLUME OF GASES AT ATMOSPHERIC PRESSURE AND 32 DEG. F.

Substance	Molecular Symbol	Relative Density Air = 1	Relative Density Hydrogen = 1*	Weight per Cu.Ft. Lb.	Cu.Ft. per Lb	Value of Constant R in $PV = RT$
Air	...	1 0000	...	0.08071	12.390	53.33
Oxygen	O_2	1 1053	16	0.08921	11.209	48.24
Hydrogen	H_2	0.0696	1	0.0562	177.936	765.8
Nitrogen	N_2	0.9673	14	0.07807	12 809	55 13
Carbon monoxide	CO	0.9672	14	0.07806	12.811	55.15
Carbon dioxide	CO_2	1.5291	22	0.12341	8 103	34.88
Methane	CH_4	0.5576	8	0.04500	22.222	95.64
Acetylene	C_2H_2	0.9200	13	0.7425	13.468	57.97
Ethylene	C_2H_4	0.9674	14	0 7808	12.807	55.12
Ethane	C_2H_6	1.0494	15	0.8470	11.806	50.81
Sulphur dioxide	SO_2	2.2639	32	0.18272	5.473	23.56
Carbon†‡	S_2	.	...	145	0 0069	......
Sulphur	.	. ..	...	125	0 0080	....

* Based on approximate molecular weights. † Solid. ‡ If carbon can be conceived to exist as a gas, under standard conditions its relative density would be 0.820; its weight per cubic foot 0.0668 lb., and its volume 14.97 cu.ft. per pound.

Experiment shows that if the temperature of a perfect gas at 32 deg. F. is increased one degree, the pressure being kept constant, the gas expands $\frac{1}{491.64}$ part of its volume. If such a rate of expansion per degree increase in temperature held good at all temperatures, and experiment shows that such is the case above 32 deg. F., if its pressure is kept constant, the gas would double in volume with an increase in temperature above 32 deg. of 491.64 deg. F.

Since the volume of a gas at constant pressure varies as the absolute temperature [—460 deg. F. is absolute zero], if one pound of gas is at a temperature of 60 deg. F. and a second pound at 500 deg. F., the respective volumes at a given pressure would be in the ratio of 60 + 460 = 520 to 500 + 460 = 960.

The section on specific heat is particularly commendable. Mr. Pratt points out that in computations on combustion the mean specific heat and the specific heat at constant pressure should be used. He gives the values in Table III (Table 7 in his book) as the most authoritative at 60 and 600 deg. F.

TABLE III. MEAN SPECIFIC HEAT AT CONSTANT PRESSURE AND ORDINARY TEMPERATURES

Substance	Molecular Symbol	Mean Specific Heat 0–60 Deg. F.	Mean Specific Heat 0 600 Deg. F
Air	....	0.2381	0.2484
Oxygen	....	0.2160	0.2211
Hydrogen	....	3.3850	3.4750
Nitrogen	....	0.2349	0.2406
Carbon monoxide	....	0.2349	0.2406
Carbon dioxide	....	0.2008	0.2214
Water vapor	....	0.4542	0.4586
Methane	....	0.498	0.649
Ethylene	....	0.348	0.461
Sulphur dioxide	....	0.1544	......

With the data of Table 8 in the book available, the development of formulas to give directly the theoretical amount of air necessary for the perfect combustion of any fuel is simple. Such formulas are given, beginning on page 49.

Mr. Pratt strikes a responsive chord in the reviewer when he says, on page 47: "It seems proper to emphasize here the necessity, where accurate results are desired, of considering flue-gas analyses *only* in conjunction with analyses of the fuel burned. As an example of the errors that may arise where the two analyses are not considered together, we may take the tables of preventable losses corresponding to varying percentages of carbon dioxide present in the flue gases, which are given in numerous publications.

Such tables give an arbitrary percentage of carbon dioxide, which, if it could be obtained, would represent no preventable loss, with increasing losses for lesser percentages of carbon dioxide. For any fuel there will be a definite percentage of carbon dioxide that must correspond to perfect combustion and therefore to zero preventable loss; but such percentage will vary not only for different classes of fuel, but even widely with different fuels of the same class. How wide this variation in carbon dioxide may be for perfect combustion with different fuels is indicated by the computations of combustion data given later [in the book], the range in examples of fuels taken being from 9.4 per cent. in the case of byproduct coke-oven gas to 25.1 per cent. for blast-furnace gas.

The book is 6 x 9 in., 114 pages. Frankly, it is not suited to the man who has not a fairly good "grounding" in the chemistry of combustion. Others would do well to gain a working knowledge of that subject before using the book.

In an early issue *Power* will publish some of the computations of combustion data which form the eleventh section of the book.

Oxyacetylene Welding and Cutting

The following rules for operation of oxyacetylene welding and cutting have been adopted by the Western Pennsylvania Division of the National Safety Council:

1. Under no condition should acetylene be used where the pressure is greater than 15 lb. per square inch.

2. Special care should be given to the storage of oxygen and acetylene tanks. Acetylene is classed as an explosive as other hydrocarbon gases and only a limited number of containers should be stored in one place. Oxygen tanks should be stored in a separate place from acetylene tanks.

3. Oxygen and acetylene tanks should not be allowed to remain near stoves, salamanders, furnaces, steam heaters or other sources of heat and should not be exposed unnecessarily to the direct rays of the sun, as an increase in the temperature of the gas will cause a corresponding increase in the pressure within the tank. Any excess of heat may also soften the fusible safety disk with which the tank is provided, causing it to blow out and permit the gas to escape.

4. Oxygen tanks should never be handled on the same platform with oil or grease which might find their way into valves on the tanks.

5. Oxygen and acetylene tanks should never be dropped or handled roughly and should never be stood on end unless fastened so as to prevent them from falling over.

6. Tanks should not be handled by crane, either magnetic or mechanical.

7. All empty tanks should be marked plainly with the word "empty" and returned promptly to the storeroom.

8. An open flame should never be used for the purpose of discovering leaks in acetylene tanks. Leaks can generally be detected by the odor of the acetylene gas, and their location can be determined by applying soapy water to the surface of the tank and watching for the soapy bubbles formed by the escaping gas.

9. No repairs to oxygen or acetylene tanks or equipment should be made or attempted. All defects should be reported promptly to the foreman, and by him to the manufacturer.

10. Leaking acetylene tanks should not be used, but should be placed in the open air and all open lights kept away from them. All leaking acetylene tanks should be reported promptly to the foreman and immediately returned to the manufacturer.

11. All open flames should be kept away from any place where there is any possibility of acetylene escaping.

12. Care should be taken to protect the discharge valves of the tanks from being bumped, as a jar may damage the valve and cause it to leak.

13. Grease in contact with oxygen under pressure may cause spontaneous ignition. Great care should be taken not to handle threads or valves with oily hands or gloves, and gages should not be tested with oil or any other hazardous carbon. If a lubricant must be used, the purest glycerin is permissible.

14. Gages, apparatus and torches requiring repairs should be sent to the manufacturer, and local repairs should not be attempted. Valve seats should never be replaced except by the manufacturer.

15. The use and operation of the pressure regulator or reducing valve on oxygen or acetylene tanks should be as follows: (a) Open the discharge valve on the tank slightly for a moment and then close it. This is to blow out of the valve any dust or dirt that might otherwise enter the regulator. (b) By means of the stud or nut connection on the regulator, connect the regulator to the discharge opening of the tank. (c) Release the pressure-adjusting screw of the regulator to its limit. (d) Open the needle valve slightly if there is one. (e) Open the discharge valve on the tank gradually to its full width. (f) Open the needle valve to its maximum if there is one. (g) Adjust the pressure regulating screw until the desired pressure is shown on the low-pressure gage.

16. The discharge valves on the tanks should be opened slowly and care should be taken to avoid straining or damaging them by the use of a hammer or improper wrench. A special wrench should be made for use in opening these valves in case they stick.

17. When the operation of the cutting or welding torch is stopped for a short time, the needle valve on the regulator should be closed, or the pressure-adjusting screw should be released to keep the pressure off the hose. The torches should be opened momentarily to let the pressure out of the hose lines.

18. All tanks should be inspected at the close of the day's work.

19. Proper precautions should be taken to protect the hose from flying sparks.

20. All hose should be examined periodically at least once every week. This should be done by cutting the hose off

at the end of the connection and examining it. In addition, after a few months' use, the hose should be cut off about two inches back of the connection and examined for defects. A defective hose should never be used.

21. Special care should be taken to avoid the interchange of oxygen and acetylene hose or piping, as this might result in a mixture of these gases that would be highly explosive. The practice of using right and left-hand threads is recommended.

22. White lead, grease or other similar substances should never be used for making tight joints. All joints and leaks in equipment should be made tight by soldering or brazing.

23. The oxygen and acetylene valves at the base of the torch should be tested daily for leaks.

24. Where hydrogen or other gas is used instead of acetylene, the same precautions should be observed as for acetylene.

25. A fire extinguisher should be carried as regular equipment to be used in case of fire.

26. Men using welding apparatus should wear suitable welding goggles for eye protection, having frames that are nonconductors of heat (not celluloid), side shields to protect against hot particles of metal, and lenses of proper color.

27. Operators' clothing should be fireproof.

28. If valves become frozen, they should be thawed by hot water, not by flame or hot metal rod.

29. Home-made generators should never be used as they are unsafe. As the Board of Underwriters has jurisdiction over all generators, only generators permitted by the underwriters should be used.

30. Where acetylene is used from generators or is piped through the plant, an approved water seal should be interposed between the generator and the piping system and individual water seals should be placed at each blowpipe. Water seals should be inspected daily, without fail.

31. Portable generators should not be used inside of the building.

32. Safety devices on tanks, generators or apparatus should not be removed or tampered with.

33. In welding brass or bronze, injurious fumes may be given off, making it desirable to wear a respirator.

34. Smoking while on duty should positively be prohibited.

35. Electric lights in a generator house should be inclosed in vapor-tight globes protected by the regulation guard.

36. Snap switches should be placed outside of the generator house in a suitable place, provided the house is isolated.

37. Piping which is used to carry acetylene or hydrogen should be painted a distinctive color so that it will not be possible to mistake that line for anything else.

38. The manufacturers should provide couplings for the hose which cannot be mistaken and put on the wrong hose. If the couplings could be made with proper connections, it would be impossible to make any mistake.

39. In storage houses where hydrogen or acetylene tanks are stored, the wiring should conform to the same rules as for the generator house so that it would be impossible to cause an explosion from defective wiring or a break in the bulb.

40. The valves on the piping should contain neither copper, brass nor bronze.

41. In opening the outlet valve of a full tank, do not remove the regulator.

42. The operator should not stand in front of the gages when opening the discharge valves on the tank. If the pressure goes off suddenly, it may possibly destroy the gage, and if it does, the glass and parts will be blown out at the front.

43. A label should be placed on every tank of oxygen that comes into any mill, that it should be kept away from grease. Some of the manufacturers put on a tag while others do not.

44. Acetylene is now capable of making a 24-in. cut. Beyond that it is necessary to use hydrogen.

New Society of Massachusetts Engineers

The initial meeting of the Engineering Society of Western Massachusetts was launched at a dinner of over 300 at the Hotel Kimball, Springfield, on the evening of Apr. 16. The speakers were Prof. L. P. Breckenridge, who discussed engineering organizations; W. S. Murray, who spoke on the conservation of natural resources with particular reference to a super-power system covering the territory between Boston and Washington; and Dr. George Otis Smith, director of the Geological Survey, who also spoke upon the power problem.

During the course of the evening there were received 1072 applications for membership. The following officers were elected: President, Charles L. Newcomb; vice presidents, C. C. Chesney and George E. Williamson; secretary and treasurer, W. E. Holmes. The following directors were also elected: Dr. H. C. Emerson, F. O. Wells, S. M. Greene, J. C. Robinson, E. E. Lochridge and G. P. B. Alderman.

The membership is divided into four classes: Honorary, full members, associate members and juniors. The initial fees and dues are each $5 for the three first classes and $3 for the fourth class. The third Tuesday in May has been fixed as the date for annual meetings.

New Publications

THE GREEN BOOK

Containing nearly 100 pages, the "Green Book, Progressive Combustion," just issued by the Green Engineering Co., of East Chicago, Ind., is an excellent example of modern publicity methods now favored by the progressive manufacturer. It is not the old-time catalog. Green products are thoroughly illustrated and the construction made evident, but the discussion is on an engineering basis. The book in fact is a treatise on combustion, including a survey of the coals of the world, their typical analyses and burning characteristics. The latter is such desirable information that in itself it should create a large demand for the new publication.

As an introduction the economic features of mechanical stokers, such as labor saving, fuel saving, increased capacity and smokelessness, are discussed. Coals are classified as to grade and firing characteristics, and attention is given to the four requirements that make a stoker automatic. The Green chain grates of the K and L types are fully illustrated and improvements such as rear drums in place of sprockets, chain skids in lieu of rolls, a perfected air-sealing system and water-cooled rear girder and ledge plates, emphasized. There is description of other Green products such as the "Sealflex" ventilated arch, the pressure waterback, the steam-jet ash conveyor and the cast-iron storage hopper.

A 17-page section devoted to combustion engineering gives the fundamentals of combustion, furnace design and draft, including chimney and breeching design, draft loss, combustion rates and boiler capacities. An instructive feature is the presentation of ten typical settings for different types of boilers equipped with chain grates to meet varying conditions.

In the concluding section coals of the world receive general comment and estimates are given of the coal reserves in North and South America, Africa, Asia, Europe and Oceania. Following are proximate analyses of these coals by name of seam or bed in the various states and countries in the United States and in the various foreign countries producing coal. Such information is most interesting and valuable to the engineer and should prove an excellent guide in the purchase of fuel or in the design of the boiler plant to burn a specific coal.

Obituary

George H. Phillips, president and treasurer of the Hewes & Phillips Iron Works, Newark, N. J., died at his home in Brielle, N. J., on the afternoon of Apr. 22. He had not been in the best of health for a year, but his illness took a serious turn only about a week before his death. Mr. Phillips was born in the old Phillips homestead on Lincoln Ave., Newark, over sixty-six years ago and lived in that city practically all his life, having removed to Brielle only five years ago. He received his early education at Newark Academy and the Hill School, Pottstown, Penn., after which he entered Cornell University. On his graduation from the university he became associated with the iron works in which his life has been spent. He was unmarried and is survived by three brothers and three sisters.

Marshall Ten Broeck Davidson, president of the M. T. Davidson Co., builders of the well-known line of "Davidson" pumps and pumping engines, died at his home in Brooklyn on Apr. 10. Mr. Davidson was one of the oldest members of the American Society of Mechanical Engineers, also a member of the Society of Naval Architects and Marine Engineers, the Naval Order of the United States, Associate Society U. S. Grant Post, No. 327, the Columbia County Association and life member of the Navy League. He was born in Albany, in 1837, and from his early boyhood showed great interest in steam machinery, particularly the locomotive and steamboat engines. In 1857 he entered a marine-engine machine shop, and later went to sea as assistant engineer. Upon the breaking out of the Civil War, he was assistant engineer on a steamer running from San Francisco to the various settlements on Puget Sound. He came east in 1862 as volunteer, second-assistant engineer in the naval service, but was requested to accept a position as chief engineer of an army transport, building at Wilmington, Del. At the close of the war, he became a contracting engineer, and in 1878 started the business which is now carried on in Brooklyn, N. Y., building pumps and pumping engines.

Personals

Alex Girtanner, formerly vice president of the American Steam Conveyor Corp., of Chicago, Ill., is now president of the Girtanner Engineering Corp. of New York, with offices at 1400 Broadway.

R. E. Thompson has been appointed manager of the Deming Ice and Electric Co., Deming, N. M., to succeed M. E. De France, who has gone to Trinidad, Colo., as superintendent of power for the Trinidad Electric Transmission Railway and Gas Co.

Engineering Affairs

The Canadian Association of Stationary Engineers will hold its annual convention and exhibition of power-plant equipment and supplies at Convention Hall, Brant Ave., Brantford, June 24, 25 and 26. An elaborate program has been provided, covering both the presentation of technical papers and special features.

Miscellaneous News

The Tallahassee Light and Power Co.'s plant was totally destroyed by fire Apr. 12, plunging the capital city of the state into semi-darkness, with the legislature in session and no adequate means of lighting the capitol, hotels or homes. The loss of the plant is estimated at $75,000.

Business Items

The Bailey Meter Co. will move its main office and works from Boston to Cleveland, Ohio, on May 1. The Boston office, with H. D. Fisher as manager, is retained to handle sales and engineering service work in the New England district. For the present New York and Philadelphia districts will be covered from Boston and all other districts will be covered from Cleveland.

Ball Bearing Manufacturers' Combine—Of interest to all users of bearings is the reorganization on May 1, whereby the products of the Hess-Bright Manufacturing Co., the S K F Ball Bearing Co., the Atlas Ball Co. and the Hubbard Machine Co. will be sold through one central organization. The new company, under the name of S K F Industries, Inc., will offer a comprehensive line of ball bearings, including the Hess-Bright deep-groove type, S K F self-aligning radial and thrust bearings, ball bearing pillow-blocks and shafting hangers.

The Curtis & Curtis Co., Bridgeport, Conn., has just completed an important addition to its plant. The new building is 150 x 125 ft. and includes an exhibition room and a new hardening and tempering department with all latest facilities.

Akerlow & Lundquist have opened an office at 415 Seventeenth St., Denver, and besides having the agency for boiler-room equipment, they will do general engineering work for power plants and coal and oil users.

The Chicago Pneumatic Tool Company has moved its Milwaukee office from Room 1305, Majestic Building, to Room 1418 in the same building, where more convenient quarters necessitated by the growing business of the company in this district have been obtained.

Trade Catalogs

Chas. A. Schieren Co., New York City, has issued Catalog No. 10 on "Schieren Leather Beltings," describing the different grades of belting, rawhide rope, cut lacing, lace leather, hydraulic leather, packing, belt cements, dressings, etc., with the general price list for each.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.35
Philadelphia, gross tons	4.20@4.90	5.00@5.40
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.65

Pocahontas and New River are quoted at $4.70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5.95	$7.80	Pea	4.80	6.55
Egg	5.85	7.70	Buckwheat	3.40	5.15
Stove	6.10	7.95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.80 @ 3.10	2.95 @ 3.25
Clearfield County	2.65 @ 2.95	....
Reynoldsville	2.65 @ 2.85	2.85 @ 2.95
Quemahoning	2.75 @ 2.95	2.95 @ 3.10
Somerset County (best grades)	2.75 @ 2.95	2.95 @ 3.10
Somerset County (poorer grades)	2.25 @ 2.50	2.50 @ 2.75
Western Maryland	2.25 @ 2.75	2.50 @ 2.75
Fairmont	2.10 @ 2.35	2.35 @ 2.50
Latrobe	2.10 @ 2.25	....
Greensburg	2.35 @ 2.40	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6.10	7.95	Boiler	2.50	3.50
Nut	6.20	8.05	Barley	2.25	3.15
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

	Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
	Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2.30	.
2-in. lump			2.15

Williamson-Franklin rate to St Louis is $1.07½: other rates 92½c

New Construction

PROPOSED WORK

Mass., Campello—H. E. Keith & Co. will soon award the contract for the construction of a 64 x 71 ft. power house. Estimated cost, $56,000. Jenks & Ballou, 735 Grosvenor Bldg., Providence, R. I., Engr. Noted Jan. 21.

Mass., Lynn—J. Grossman, 401 Grossman Bldg., will install a steam heating plant in the 7-story apartment hotel which he plans to build on Lynn Shore Dr. and Wade St. Total estimated cost, $250,000.

Mass., New Bedford—H. T. Borden, Chn. of the Comn., 154 Fair St., will soon award the contract for the construction of a power house, laundry, etc., in connection with the hospital group, which it plans to build on Mt. Pleasant, Myrtle, Van Buren and Jefferson St. Total estimated cost, $100,000. J. R. Worcester & Co., 79 Milk St., Boston, Engr. Noted Feb. 11.

Conn., Bridgeport — The Carlisle-Cord-Tire Co., Andover, Mass., will install a steam heating plant and electric power in the 1-story, 150 x 250 ft. factory which it plans to build on Fairfield Ave. Total estimated cost, $100,000.

Conn., Bristol—E. Ingraham Co., 392 North Main St., has awarded the contract for the construction of a 5-story, 50 x 100 ft. factory to the H. Wales Lines Co., 134 State St., Meriden. A steam heating system and electric power will be installed in same. Total estimated cost, $100,000.

Conn., New London—The New Haven Dairy Co., Hazel St., New Haven, plans to build a 2-story artificial ice plant on Pequot Ave. Estimated cost, $50,000.

Conn., Wallingford—The Masonic Charity Foundation Co., Meriden, has awarded the contract for the construction of a 4-story, 86 x 105 ft. home to the H. Wales Lines Co., 134 State St., Meriden. A Brownell vapor heating system will be installed in same. Total estimated cost, $150,000.

N. Y., Antwerp—The Antwerp Light & Power Co. has had plans drawn for the development of the company's water power on the Indian River. Plans include the construction of a dam, flume and power house, transmission line and the installation of generator units. Address J. A. Baumert, Antwerp.

N. Y., Buffalo—The Armour Grain Co., Abbott Rd., is in the market for conveying and transmission equipment and grinders to be installed in the addition to its mill which it plans to build. Estimated cost, $25,000.

N. Y., Cambridge—The Rice Seed Co. will install a heating plant, temperature and humidity controlling equipment, etc., in the 75 x 275 ft. storehouse and shipping building which it plans to build near the Delaware and Hudson R.R. Estimated cost, $35,000.

N. Y., Long Island City—The Board of Education, 500 5th Ave., New York City, will install a steam heating plant in the 3-story, 100 x 100 ft. high school addition which it plans to build on Wilber Ave. Total estimated cost, $500,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Long Island City—Loft, Inc., Broome and Center St., New York City, will install a steam heating plant in the 5-story, 150 x 200 ft. factory which it plans to build on Vernon Ave., Dayton to Hamilton St. Total estimated cost, $850,000. J. P. Dunn, 514 1st Ave., New York City, Arch.

N. Y., Madison—The War Department plans to install a new steam heating plant in the old stone quarters here. Estimated cost, $60,000.

N. Y., New York—Cuneo & Posta, 73 Washington Sq., will install a steam heating plant in the 5-story, 100 x 130 ft. garage which they plan to build at 541-551 West Broadway. Total estimated cost, $100,000. F. E. Vitolo, 56 West 45th St., Arch.

N. Y., New York—R. H. Macy & Co., Bway. and 34th St., has awarded the contract for the construction of a 17-story, 50 x 200 ft. addition to its department store at 149-155 West 34th St. to Marc Eidlitz, 30 East 42nd St. A steam heating plant will be installed in same. Total estimated cost, $500,000.

N. Y., New York—The National Association Building Corp., 25 West 45th St., will install a steam heating plant in the 20-story arcade store and other building which it plans to build at 37 West 43rd St. through to 26-28 West 44th St. Total estimated cost, $800,000. Starrett & Van Vleck, 8 West 40th St., Engr.

N. Y., New York—The New York Infirmary for Women & Children, 321 East 15th St., will install a steam heating plant in the 44 x 60 ft. dispensary which it plans to build at Livingston Place and 15th St. Total estimated cost, $155,000. Butler Rodman, 56 West 42nd St., Arch.

N. Y., New York—M. Rubin, 1969 Amsterdam Ave., will install a steam heating plant in the 2-story 100 x 203 ft. garage which he plans to build at Jumel Pl. and 167th St. Total estimated cost, $200,000. F. Caplin, 16 Court St., Brooklyn, Arch.

N. Y., Salisbury Center—G. W. Boyle, Pur. Agt., Herkimer Co. (Herkimer), will install a steam heating system in the tuberculosis hospital which will be built on the Heller Farm here. Total estimated cost, $100,000.

N. J., Cape May—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a cold storage building at the Section Base here. Estimated cost, $50,000. Specification No. 3685. Noted Dec. 31.

N. J., Hopewell—W. C. Slack, 42 Fisher Pl., Trenton, plans to build a 1-story, 42 x 120 ft. refrigerating plant here. Estimated cost, $18,000.

N. J., Newark—Otto Heineman Co., Inc., 145 Jackson St., will install a steam heating plant in the 4-story, 80 x 400 ft. factory which it plans to build on Thomas St. Total estimated cost, $500,000. R. G. Cory, 39 Cortlandt St., New York City, Engr.

Penn., Pittsburgh—The Y. M. C. A. will install a heating system in the 4-story, 81 x 120 ft. association building which it plans to build on Center and Francis St. Total estimated cost, $100,000. E. B. Lee, Chamber of Commerce Bldg., Arch.

Md., Highlandtown (Baltimore P. O.)—Jones & Lamb Co., Pennsylvania and Fulton Ave., Baltimore, plans to remodel the plant of the Monumental Brewery Co., and construct several buildings on Lombard St., same to be used as meat packing plant and oil refinery. A steam heating system, engines and boilers will be installed in same. Total estimated cost, $500,000. C. C. Comstock, 110 West 40th St., New York City, Engrs.

Ohio, Cleveland—G. W. Hale, Leader-News Bldg., will install a steam heating system in the 3-story, 165 x 180 ft. garage which he plans to build on East 9th St. and Bolivar Rd. Total estimated cost, $250,000.

Ohio, Cleveland—The Purity Ice Cream Cone Co., 5119 Euclid Ave., will install a steam heating plant in the 4-story factory which it plans to build at 8804 Hough Ave. Total estimated cost, $100,000.

Ohio, Parma—The Board of Education will install a steam heating plant in the 3-story school which it plans to build. Total estimated cost, $100,000. Wright & Hohl, 407 American Trust Bldg., Cleveland, Arch.

Mich., Detroit—The Grand River Parish, Grand River and McGraw St., will install complete steam heating equipment in the 2-story 70 x 180 ft. school which it plans to build on Grand River and Quincy Ave. Total estimated cost, $130,000. Van Leyen, Schilling and Keough, 1121 Union Trust Bldg., Arch.

Mich., Detroit—The Seamless Steel Tube Co., 841 West Jefferson Ave., plans to build a power plant in connection with the factory which it plans to build on Wyoming and West Warren Ave. Total estimated cost, $1,700,000. A. A. Templeton, Pres.

Wis., Waupaca—F. H. Josslyn, Algoma Bldg., Oshkosh, plans to build a 2500 hp. hydroelectric power plant on the Little Wolf River. Estimated cost, $200,000. E. Orbison, Appleton, Engr.

Minn., Brainerd—The city will receive bids until May 8 for building a water system. Work involves (a) distribution system (1) furnishing pipe and castings, f.o.b. Brainerd, (2) fire hydrants, (3) valves and boxes, (4) laying pipe; (b) buildings including pumping station, pump houses, pump pits and manholes for 2 tubular well groups, also 800,000 gal. reservoir; (c) pumping plant including the removal of two 6-in. motor driven centrifugal pumps to the new pumping station and installing 2 motors and engine driven centrifugal pumps for well system together with necessary pipe and fittings. L. P. Wolff, Guardian Life Bldg., St. Paul, Consult. Engr.

Minn., Virginia—The Commissioners of St. Louis Co. (Duluth) will install a steam heating and mechanical ventilating system in the 3-story addition to the court house which they plan to build. Total estimated cost, $150,000. W. H. Bargen, Co. Aud.

Neb., Omaha—The Skinner Packing Co., 904 First National Bank Bldg., will receive bids until May 15th for the construction of an 8-story, 99 x 132 ft. cold storage plant on 12th and Douglas St. Estimated cost, $500,000. H. C. Christianson, 7258 Union Ave., Chicago, Ill., Engrs. Noted Apr. 1.

Mo., St. Louis—The St. Louis Wholesale Cut Flower Co., 1419 Pine St., will install a refrigerating system in the 50 x 109 ft. flower storage building which it plans to build at 1406-8 Pine St. Estimated cost, $50,000. Grewe Construction Co., Century Bldg., Engr.

Mo., St. Louis—Swift & Co., 39th and Papin St., will soon award the contract for the construction of a 1-story, 60 x 60 ft. addition to its boiler house. Estimated cost, $70,000. K. A. Green, Supt.

Ore., Warrenton—The Mountain Meat Co., Portland, is having plans prepared for the construction of a cold storage plant here. Address W. C. Pratt, c/o company.

Cal., Sacramento—The city plans election in May to vote on $2,400,000 bonds to purchase a site and build a pumping plant, filtration plant and caisson in the Sacramento River. F. C. Miller, City Hall, Engr.

Que., Montmagny—The city plans to build a power house, dam, electric line and install machinery. Estimated cost, $100,000.

P. I., Cavite—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install power plant equipment here. Estimated cost, $90,000. Specification No. 3871.

CONTRACTS AWARDED

N. Y., Ogdensburg—The Board of Education has awarded the contract for installing a heating and ventilating system in P. S. No. 2 to the American Warming & Ventilating Co., 317 Pennsylvania Ave., Elmira. Estimated cost, $7427.

N. Y., Rockaway—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for the construction of a pump house for electric remote control gasoline system at the Naval Air Station here from C. Mead, 38 Park Row, New York City, $1664; Rangley Construction Co., 405 Lexington Ave., New York City, $1739 (45 days); Post & McCord, 101 Park Ave., New York City, $1923 (60 days). Specification No. 3836.

N. Y., Thiells—L. F. Pilcher, State Architect, has awarded the contract for building an addition to the central heating plant at Letchworth Village, to the G. B. Wright Co., Garnersville, $32,200; contract for electric work has been awarded to the W. H. Straut Co., 14 New Main St., Haverstraw, $850.

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing pumping equipment in Navy Yard here to the W. G. Cornell Co., Colonial Trust Bldg. Estimated cost, $7286 (45 days).

Wis., Menasha—The Gilbert Paper Co. has awarded the contract for the construction of a 60 x 167 ft. power house to C. R. Meyer Sons, 50 State St., Oshkosh. Estimated cost, $75,000.

Ore., Salem—The Pheasant Northwest Products Co., Ferry St., plans to build a boiler house adjoining the company's plant between Trade and Ferry St. Estimated cost, $5000. Work will be done by day labor.

Cal., Glendale—The city has awarded the contract for furnishing electrical materials as follows: U. S. Steel Products Co., Rialto Bldg., San Francisco, 13,600 lbs. 2.-0 triple braid copper wire at $19.42 per 100 lbs. f.o.b. Los Angeles; General Electric Co., Rialto Bldg., San Francisco, 60 kv.-a., 150 ampere type C induction feeder at $2238, f.o.b. Los Angeles; Pacific Electric Manufactdring Co., 827 Folsom St., San Francisco, 3-pole, single-throw, 15,000-volt, 200-ampere, oil circuit breaker at $725, f.o.b. Los Angeles.

Cal., Pasadena—The City Light Department has awarded the contract for furnishing electrical material as follows: the Ananconda Copper Co., 42 Bway., New York City, copper wire; Maloney Electric Co., San Fernando Bldg., Los Angeles, 2 transformers.

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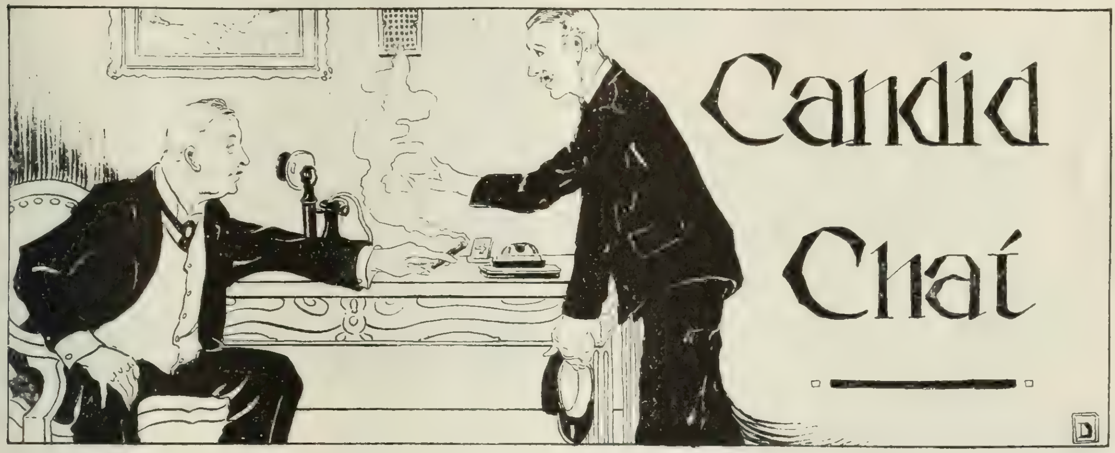
Volume 49 New York, May 6, 1919 *Number* 18



Setting the Boss Straight

By J. O. Batzer

With a pleasant, "Good morning, sir," the chief engineer entered the luxurious office occupied by the president of the great corporation. The day was dark and cold, and the cozy comfort of a properly heated and lighted room contrasted pleasantly with the gloom outside.

"How do you do, chief," the president responded. "What is your trouble today?"

"None at all," the engineer answered. "I only wanted to see whether you were comfortable this morning."

"Thank you. My office seems very agreeable. How are things going down in your plant this weather?"

"Very smoothly," said the engineer. "If they weren't, you'd quickly discover the fact."

"Yes, if your boilers should blow up or your engines break down, I presume that I would hear about it," the president remarked jocosely.

The engineer, who during the number of years the plant had been in operation had never had the honor of a personal inspection of his domain by the "big boss," thought the time opportune to give the president a better understanding of the importance of the plant service, so he replied:

"Yes, you would undoubtedly hear about it; but such a calamity would not be required to spoil the comfort of your office. A little slip or inattention on the part of one of the lowest paid plant employees would be sufficient to ruffle your feelings and interfere with your important work."

The president looked interested.

"Chief," he said, "I must admit that I am unfamiliar with the details of your plant, but I also am unconscious that my peace of mind depends solely on the successful operation of your plant."

The engineer hesitated for a moment, looking around the room. The lights were bright and clear, indicating that the steam pressure was up to the notch to keep the overloaded units generating current at the required voltage. Small flags fluttered from the ventilating registers in the steady current of heated, washed and humidified air, while the smoke from the president's cigar whirled in a blue streak through the exhaust duct on the wall. The engineer smiled.

"During the years this plant has been in operation," he said, "did you ever find the elevators refuse to give you instant service?"

"No."

"Did not these push-buttons always furnish you the desired illumination?"

"They surely did."

"You never once in all these years stepped out to your lavatory to find the faucets unresponsive to your push for hot or cold water; the drinking fountain in your office bubbles cheerfully with clear, sterilized and refrigerated water; the fan systems are faithfully pumping into your room an abundance of clean, washed air with the most healthful degree of humidity, while the used air is drawn out through those registers. If you examine the recording thermometer over there, you will find that in spite of the variation of outside temperature, it shows a practically true and unbroken circle for the whole week. Are not every one of these things very essential to your comfort?"

"Yes, chief, I admit all that."

"The complex system required," the engineer continued, "for the production of all these apparently insignificant but necessary details is rather difficult to grasp; but a shutdown of even a part of the system for the shortest duration would be detrimental to your ease and comfort."

"True enough," the president remarked, "but your modern, expensive plant ought to insure continuous service without such absolute dependence on the operating force. The automatic features of an up-to date plant like ours should relieve the engineer of a great amount of work."

"But you must remember," the chief engineer retorted, "that the modern plant is dependent to a far greater degree than ever before on the unceasing attention of the operators. A plant equipped with a multitude of automatic devices does not function very long without the controlling human element. Modern mechanical developments do not eliminate labor, but elevate it to a position where it must display skill and knowledge."

The president looked out of the window in silence for a moment. Then he turned to his visitor. "Chief, your talk was very interesting. No doubt the years of splendid service of your plant have made us forget the importance of the faithful attention you and your men have given. At the first opportunity I am going to visit the plant and learn more about it."

The chief could not hide his satisfaction at this announcement.

"We shall welcome your visit," he assured the president, "even if it is only an annual inspection, for your personal interest will be a spur to greater effort for efficiency. More than that, it will make us feel that we are not buried and forgotten, but that we also are vital parts of your great organization."

Armour's Special Testing Equipment

Ingenious apparatus of unusual design for determining directly the horsepower of automobile engines, the influence of impact, bearing friction, belt slippage and heat flow through any material that can be prepared in flat slabs. Other interesting equipment at the Insitute includes a ***boiler-room control board and at complete ice-making*** *plant with facilities for measuring all heat exchanges.*

THE Research Committee of the American Society of Mechanical Enginees has inaugurated recently several activities tending toward the better use of facilities available in the laboratories of the various technical schools, universities, large industries and private investigators. One of the objects is to avoid duplication by publishing results of tests of value to the profession that have been conducted and by giving notice of interesting work to be undertaken. It is acknowledged that the equipments of certain laboratories are specially fitted for definite kinds of research, and if it were known what each had in the way of special equipment, problems would naturally go to those laboratories best fitted for the work. A survey of laboratory facilities is the first essential, and in this connection the following outlines of special testing equipment obtained from Prof. G. F. Gebhardt, of the Armour Institute of Technology, Chicago, may be of interest.

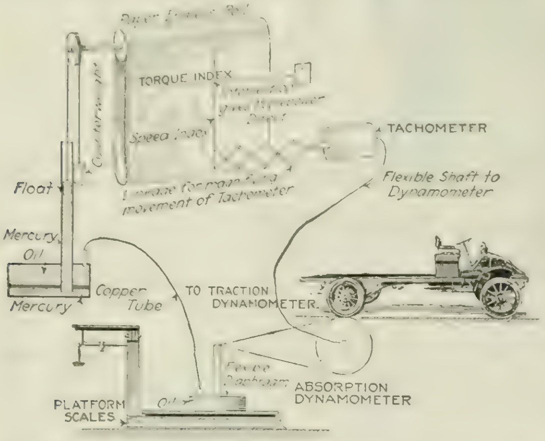


FIG. 1. DIAGRAM OF DIRECT-READING HORSEPOWER METER

Horsepower Meter—One of the most ingenious and useful of the various testing outfits in the gas-engine laboratory is the horsepower meter shown diagrammatically in Fig. 1. This apparatus enables the driver of a chassis to determine the traction effort and the horsepower delivered to the rear wheels at any instant without the need of calculation. The chassis is backed up on the test platform so that the rear wheels engage with corresponding pulleys of an absorption dynamometer and the frame of the vehicle is attached to an indicating traction dynamometer. The driver then needs only to drive the machine at various speeds, and the traction effort and horsepower developed at the rear wheels are automatically indicated by the mechanism of the meter.

Referring to Fig. 1, rotation of the rear tires is transmitted to the two large-diameter wheels of the dynamometer. The brake load on the dynamometer arm is transmitted through a copper tube from an oil-filled chamber on a platform scale to an oil reservoir, as indicated. The oil pressure, through the agency of a mercury column, actuates a balanced float, the movement of which is transmitted to an endless roll of paper. The displacement of the paper roll is a direct measure of the torque since the brake arm is of constant length. The brake is of the Alden dynamometer type, and the load required to absorb the power is controlled hydraulically from any convenient point.

The speed of the dynamometer is transmitted through flexible shafting to a special tachometer so arranged that the index needle moves axially across the paper drum. The intersection of the tachometer index with that of the torque index gives the horsepower directly. Thus a glance at the meter proper gives the load on the scale in pounds, the torque in foot-pounds, the speed of the dynamometer in revolutions per minute and the horsepower developed at the rear wheels. The scale

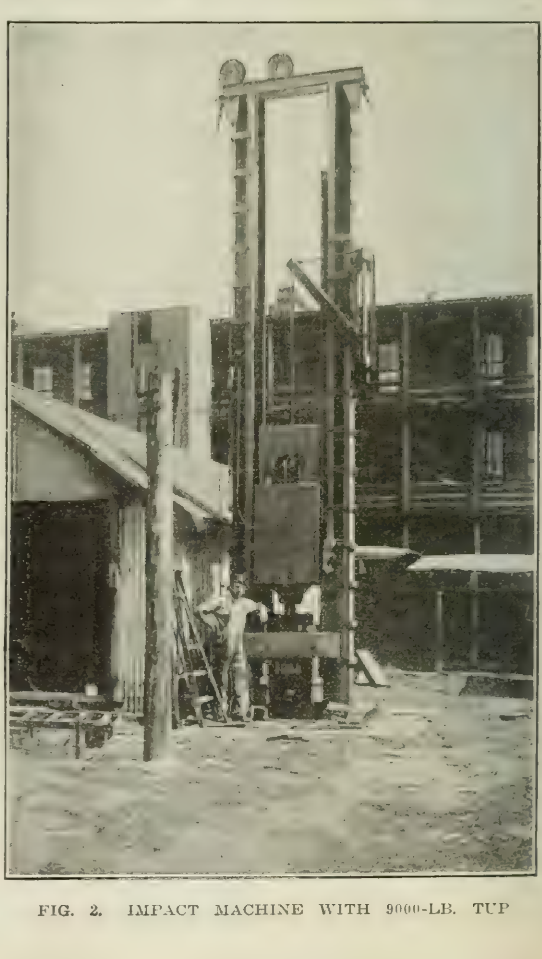


FIG. 2. IMPACT MACHINE WITH 9000-LB. TUP

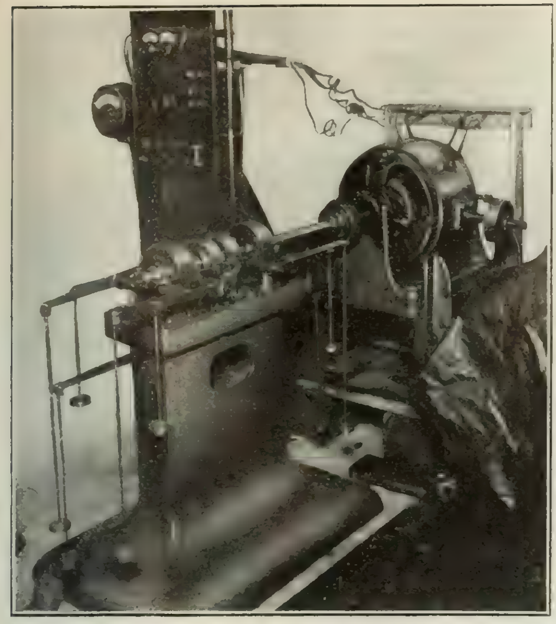


FIG. 3. BALL-BEARING FRICTION TESTING MACHINE

beam offers a check on the float mechanism, and a small setscrew in the body of the oil chamber permits adjustments to be made for any temperature variation therein.

Impact Machine—This is one of the few machines of this size in the country. The tup is a simple steel casting weighing 9000 lb. and having a maximum drop of 20 ft. It is lifted by an electromagnet actuated by a 10-hp. motor. This device is used primarily for determining influence of impact on heavy railway appliances, such as draft gears, springs, knuckles and the like.

Ball-Bearing Friction Machine—This machine (Fig. 3) differs from that ordinarily designed for this purpose in that both radial and end-load friction may be determined simultaneously or separately. The various levers exerting pressure on the bearings are so proportioned that one set of weights suffice for all conditions of loading. The device consists essentially of four ball-bearing cages (two rigid and secured to the frame and two floating but constrained against rotation) fitted with bearings and riding on a special heat-treated shaft. The radial load is applied to the bottom of the two center cages, and since all bearings are equal distances apart this radial load is uniformly distributed over each bearing. The end loads are applied through the agency of suitable levers to the bearing cages in such a manner that all end thrusts are obviated except that incident to the bearings themselves. The shaft is free to move axially, and the power absorbed in overcoming friction is measured by means of a sensitive electric cradle dynamometer. The entire construction is such that only the friction of the bearings is measured by the dynamometer.

Oil-Friction Machine—In basic principle this device is similar to the "Thurston Railroad Oil Tester," but differs considerably in detail. It is capable of measuring friction loads as high as 700 lb. per sq.in. of bearing surface. The boxes surrounding the bearing are jacketed so that any uniform temperature ranging from —20 deg. F. to 400 deg. F. may be maintained. For the lower temperatures refrigerated brine is circulated through the jackets and for the higher ranges high-pressure steam is used. With this device it is not necessary to establish thermal equilibrium between bearing friction and heat dissipation from the machine as is the case with unjacketed oil-friction machines. Total pressure, speed and temperature may be varied independently.

Belt-Testing Machine—The unusual feature of this device lies in the method of speed measurement. The horsepower input and output, total tension and stretch are obtained by the usual laboratory appliances, though attention should be called to the use of an electric cradle dynamometer for measuring power input and the liberal use of ball bearings for eliminating sliding friction. The speed of the driving and the driven pulley, slips and creeps of the belt are measured photographically. Two continuous speed counters, connected by flexible shafting to the driving pulley and driven pulley respectively, are mounted together with a split-second watch under a long-focus camera. By means of a number of nitrogen-filled lamps sufficient illumination is effected to photograph the counters and watch in one twenty-fifth of a second. By comparing the photograph taken at the

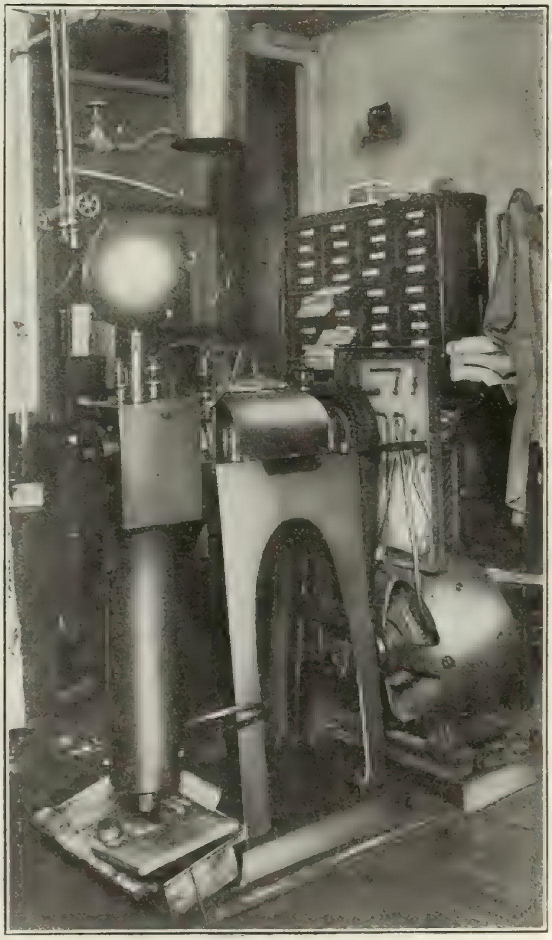


FIG. 4. OIL-FRICTION MACHINE

beginning of the run with that at the end, the total number of revolutions for each counter and the elapsed time to one-fifth of a second may be readily obtained. The counters and watch operate continuously, so that no contact mechanisms, releases or clutches are necessary when beginning or completing a run. A difference of one revolution in 30,000 per unit of time is obtained with the same degree of accuracy as one in fifty.

Boiler Control Board—In the boiler room the instrument board is of interest. It is plainly visible to the fireman when operating the boiler and contains only indicating instruments, as the recording elements are located in the engine room. Tnis board enables the firemen to note the flow of steam, flow of feed water, flue temperature, steam pressure, draft pressure drops through fuel bed, furnace and boiler and the percentage of CO$_2$ in the flue gases at any instant. In this respect it differs in no way from a number of test boards in general practice. The distinguishing features lie in the addition of a control valve, adjacent to the draft gages, for opening and closing the boiler damper, and a fuel counter. By turning the handle of the control valve the opening of the damper may be regulated to suit conditions, and the effect is at once visible on the draft gages. An indicating needle, in plain view of the fireman but not mounted on the board, shows the amount the damper is open. Since the coal burned is a washed nut of uniform size, the height of the coal gate and the speed of the chain are direct functions of the weight of coal burned. Thus an ordinary electric counter, actuated by the driving gear of the chain grate and calibrated for the given size of fuel and gate opening, records the weight of coal fired. Numerous tests show a maximum error of only 2 per cent. between the counter readings and the fuel as actually weighed. A special tachometer has just been constructed which will show the rate of combustion, pounds of coal per hour and per square foot of grate area per hour at any instant. This will be mounted on the board and will take the place of the present counter.

Thermal Conductometer—This is a particularly accurate instrument designed for measuring the heat flow through materials such as are generally used in cold-storage construction. Among such materials may be mentioned cork board, mineral wool, lith, rock cork, etc. The instrument may be used to measure heat flow through any material that can be prepared in flat slabs or plates.

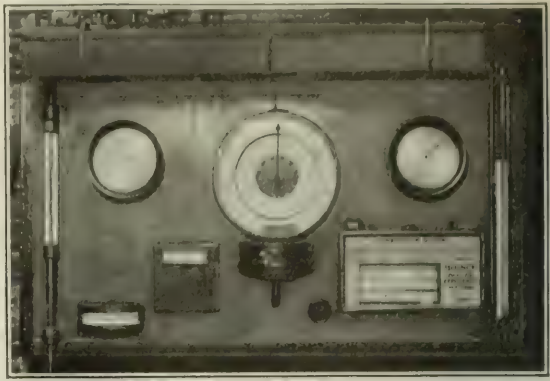


FIG. 7. BOILER-CONTROL BOARD

It consists essentially of three flat plates, each approximately 18 in. square. One is provided with a winding of resistance ribbon distributed uniformly over the surface, through which a current of electricity may be passed to heat the plate. The other plates are made hollow and are kept cool by circulating water through them.

When the instrument is in use, the hot plate is set

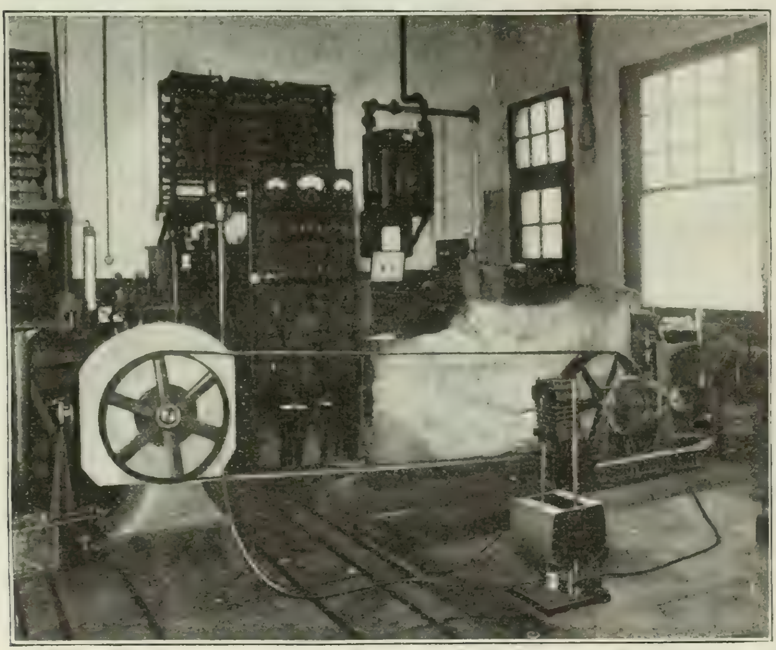


FIG. 5. BELT-TESTING MACHINE WITH PHOTOGRAPHIC SPEED MEASUREMENT DEVICES

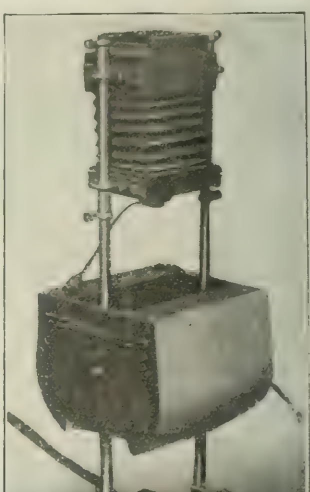


FIG. 6. SPEED-REGISTERING MECHANISM

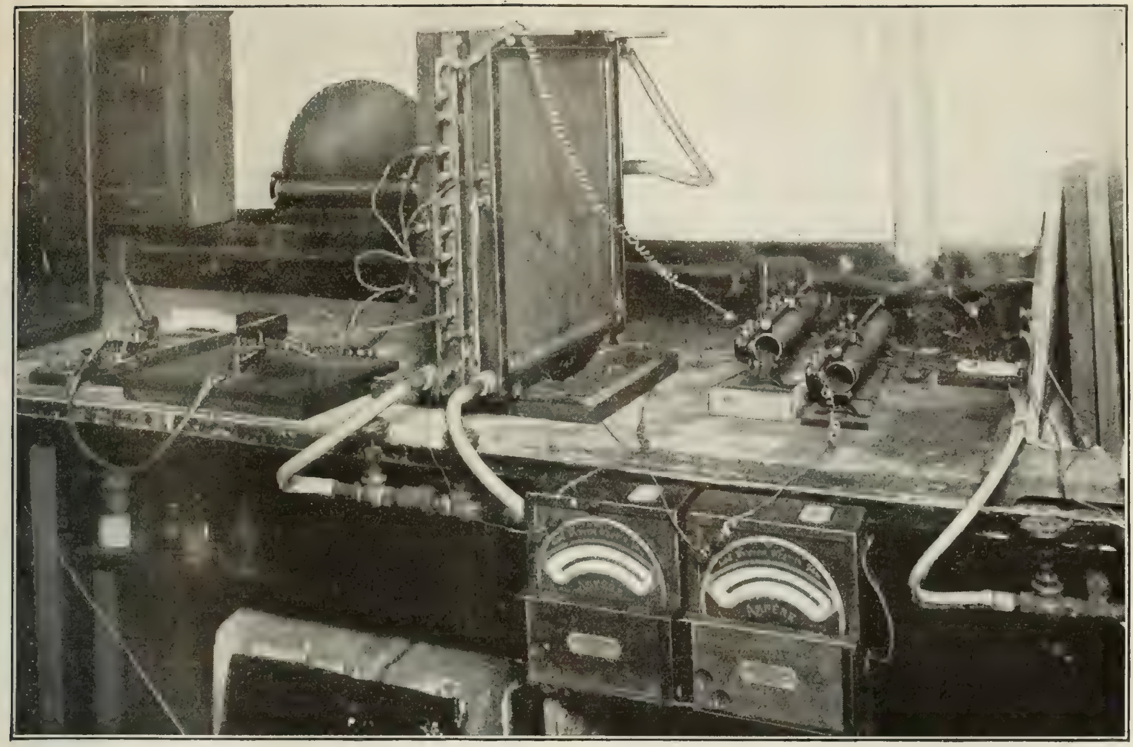


FIG. 8. THERMAL CONDUCTOMETER FOR MEASURING HEAT FLOW THROUGH CONSTRUCTION MATERIALS

up in a vertical position with a cold plate on each side. Two samples of the material to be tested are prepared, and placed one on each side of the hot plate between the latter and one of the cold plates. Thus the heat generated in the hot plate passes through the test material on both sides and into the water-cooled cold plates.

From the resistance of the winding on the hot plate

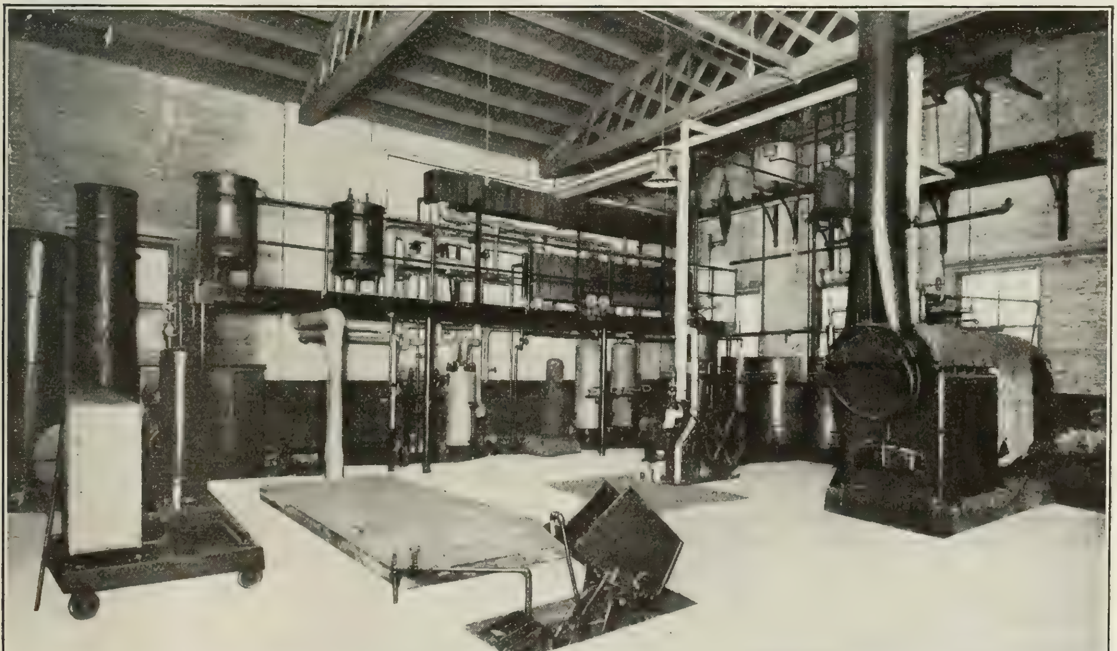


FIG. 9. COMPLETE ICE PLANT EQUIPPED TO MEASURE ALL HEAT EXCHANGES

and the current used the heat input is readily calculated. The temperature difference between the hot plate and the cold plate is measured by copper constantan thermocouples connected to a portable galvanometer. Thus since the rate at which heat is given off per unit of surface on the hot plate is known, and also the temperature difference between the hot plate and the cold plate, the heat passing through the material per degree of temperature difference is easily determined.

Ice Plant—An ice plant complete in every detail is one of the features of the laboratory equipment. It consists of a standard five-ton vertical steam-driven compressor, a double-pipe ammonia condenser, a double-pipe brine cooler, an ice tank containing 100-lb. ice cans, and a complete gravity distilling plant for the manufacturing of ice.

The apparatus is so arranged that the various heat exchanges from the "coal pile to ice ready for delivery" may be accurately determined. The quantity of ammonia circulated is obtained by means of duplicate liquid receivers placed on platform scales. Thermometer wells are placed at the various inlets and outlets of water, brine and ammonia pipes leading to and from all parts of the system. The condenser and brine cooler are insulated with six inches of granulated cork within a specially constructed tight box.

The engine is supplied with steam from a 25-hp. semi-portable internally fired boiler, which is fully equipped for standard A. S. M. E. tests. The engine can be run condensing if desired or the steam may be condensed in the atmospheric steam condenser of the distilling system.

The System Log-Sheet Index

By Frank Gillooly

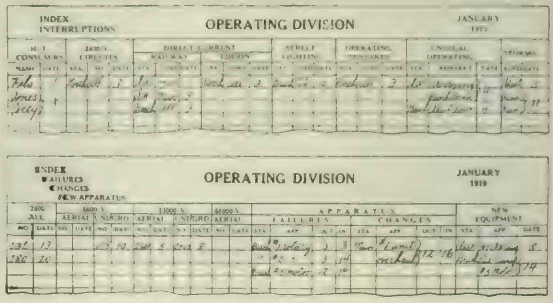
The details of last month's interruption or of last year's big shutdown are likely to be fresher in mind than the exact date of the occurrence. If some special method of filing such happenings is not pursued, to locate the record of any event might entail a day-by-day perusal of the voluminous diary. In one large system where the load dispatcher's log was the official operating record, that volume became so bulky as to necessitate some means of making its contents more accessible; and an index was devised for notating according to classification, all major operating events.

The index is filed according to months and serves the additional purpose of affording a monthly summary of events. It is made up on loose-leaf ledger sheets of the same size as the load dispatcher's log, though ultimately filed in a volume separate from that report, and the entries are made at the end of each day. Two sheets are used—a service record, shown in the upper part of the figure, and an apparatus record, in the lower part of the figure. All service interruptions are listed under the class of distribution: High-tension, or primary-voltage consumers; low-tension, alternating-current and direct-current distributions; railway; and street lighting. Storms and switching mistakes causing interruptions, are noted; as well as all out of the ordinary operating conditions.

The apparatus record gives the failures of lines and cables, according to the class of service on which they are used; failures, changes and removals on all other station apparatus, according to stations; and a record of all new equipment. Only one entry is made for each event; it gives the date, station and identity of the apparatus or load affected—excepting that a failure causing five kinds of interruptions would be considered as constituting one and causing five other events, and six entries would be made on the index. Cables are not considered as station apparatus and are listed by number only.

On the interruption report the word "all" has the meaning of "total" or "complete" interruption to the class of service denoted by the heading of the column in which it appears. If the load of one distribution circuit is lost, the number of that circuit is given; if several circuits are interrupted, the word "miscellaneous" appears; if all the load is lost, the word "all" is written.

In the two years during which it has been in use, the index has proved a valuable time saver for locating material for various reports and studies, as well as providing a complete summary of operating conditions.



INDEX
INTERRUPTIONS
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1919

SERVICE-RECORD AND APPARATUS-RECORD SHEETS

With modifications to suit local conditions the method should prove of equal value on any system, large or small, and could be made a yearly instead of a monthly record. The loose-leaf ledger has the advantage over the card-index file of being more agreeable to handle, the complete index being contained in one volume.

Engineer's Assumption of Risk

Where the engineer of a stationary engine and boiler is charged with the duty of inspecting and repairing the equipment or to report need for repairs, his employer will not be liable for his injury resulting from an explosion of the boiler due to its defective condition, the engineer having given no notice of needed repairs.

The reason for the foregoing rule relieving the master of liability to the injured servant whose duty it is to inspect and report defects is apparent. Negligence is the violation of some duty which the party charged with it is under obligations to perform, and necessarily, if there is no duty to do the thing complained of, there can be no negligence in failing to do it. The duty of the master to repair, in cases like this, arises only when he is notified by his servant of the necessity of such repair, and if the servant fails to give such notice and continues to work, he assumes the risk, and if injured he cannot look to the master. (Kentucky Court of Appeals, Drake's Administrator vs. Mountain Central Railroad Co., 208 Southwestern Reporter, 765.)

A Dutch engineer has evolved a new method of freeing boiler feed water of oil. He subjects the water to the action of 110-volt continuous current, which causes the oil particles to combine into larger masses, after which they are removed by pressure filters.

Care of Heating and Ventilating Equipment—IX

BY HAROLD L. ALT

Several vapor systems are taken up in this article and their characteristics are explained, together with information regarding some of the special apparatus used with each.

THE ordinary term "vapor system" may be interpreted as any system of steam heating that operates at or near to atmospheric pressure and in which the condensation is not returned to the boiler by a mechanical pump or other positive displacement device. Such systems are designated by many different terms and in this variety of names lies the cause of a large amount of the confusion that exists in regard to them. "Vacuum-vapor," "atmospheric," "modulated," "vapor-vacuum" and "thermo-grade" are all terms applied to the various types of such systems. There are numerous patented devices, made and developed by the various vapor heating companies, which have contributed much toward popularizing and making commercially successful the vapor heating idea.

Primarily, vapor heating plants were developed for small-residence work, but their success has gradually given them an increased field so that now they are used in the largest buildings. This justifies their discussion at considerable length.

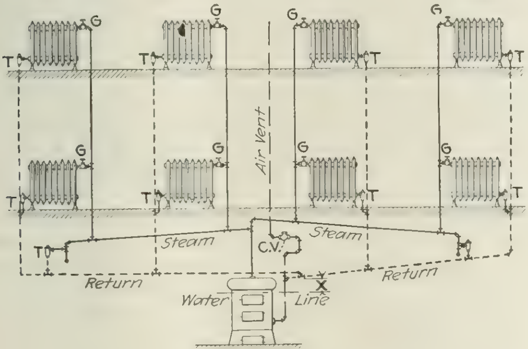


FIG. 1. PIPING OF VAPOR SYSTEM

Vapor systems may be classified as those employing traps on the radiator returns and those employing open returns. These two systems are subdivided into those returning their condensation to the boiler by gravity and those which employ a special trap of some sort to return the condensation to the boiler against the boiler pressure. The fundamental idea back of all vapor systems is that it takes a less intense fire to evaporate water at or below atmospheric pressure than it does at higher pressures. Therefore a circulation of vapor can be obtained with less fire than would be possible were it necessary to generate steam under pressure. In some systems a pressure slightly above the atmosphere is first generated in order to blow out the air and then the vapor in the system is allowed to condense and form a partial vacuum. Other systems use a slight pressure (a few ounces only) at all times, and still others endeavor to maintain a partial vacuum at all times by various expedients.

Any hot-water radiator with a graduated valve, any steam boiler with sensitive control, any two-pipe gravity system of piping with a dry return open to the atmosphere in conjunction with a thermostatic trap for each radiator may be easily converted into a true "vapor" system, as will be seen in Fig. 1. Other special devices may be added and the piping may be modified until the original layout is hardly recognizable. Steam is generated in the boiler and passes up into the steam main supplying the radiators, just as in a two-pipe gravity system, and enters the radiators through the top inlet (where usually a graduated valve is placed) and fills a portion of the radiator, as determined by the graduation of the inlet valve *G*. In entering the radiator the steam pushes the air ahead, forcing it out through the return connection at the opposite end, and in this respect the "vapor system" resembles the "vacuum system." The steam entering only at the rate permitted by the valve condenses within the radiator, the condensation passing down and out of the return connection along with the air. If the valve is opened full so that the radiator is filled with steam, the trap *T* on the return line becomes hot and closes off until sufficiently cooled condensation has collected and reduced in temperature to such a degree that the trap opens and relieves the water. The radiator traps used on the returns of a "vapor" system are identical with those used on "vacuum" systems and serve the same purpose; namely, they prevent the entrance of

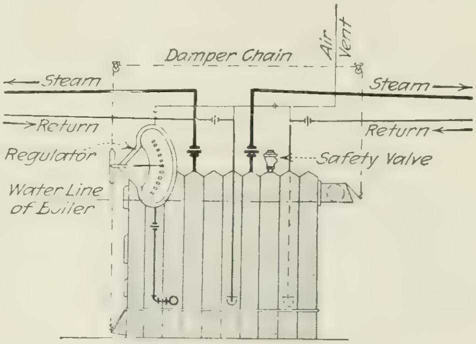


FIG. 2. REGULATOR FOR BOILER CONTROL

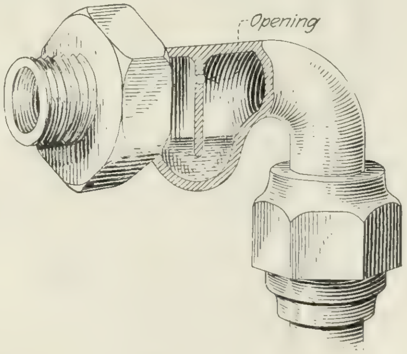


FIG. 3. RADIATOR RETURN TRAPPED ELBOW

steam into the return line and thereby prevent the accumulation of pressure in that line. The air and water then pass down the return lines to the main return and along this main to the point where it has a vent taken off; here the air and water separate, the air going out at the vent and the water flowing into the boiler.

If it is desired, this system as shown can be operated at a pressure of one or two pounds provided the distance *X* (between the water level in the boiler and the low point in the return header) is made about three feet for every pound of steam carried. Unless such a distance is maintained the water in the boiler having the steam pressure exerted on its surface, while the water in the return has only atmospheric pressure, will cause the boiler water to back up in the returns until a state of equilibrium is reached, and if the return main is too low it will be flooded and airbind the system. Should it be desired to operate the system, at times, below atmospheric pressure, an "impulse" check valve (*C. V.*) installed in the vent line will effectually prevent the air rushing back into the system when the fire goes down, and the resulting vacuum will produce a circulation of vapor throughout the system for some time.

Should it be desired to dispense with the radiator traps and use an open return, additional "condenser" surface amounting to anywhere from 10 to 25 per cent. must be installed on each radiator. The purpose of such additional surface is to care for any slight excess vapor that may be delivered to the radiator by the graduated valve when turned on full. It has been found impossible to set the graduated valves to control the vapor to any limits smaller than this, and it has proved impractical to vary the valves for every small change in radiator surface. On the other hand, if the same valve is used on a radiator of 40 sq.ft. as on one of 50 sq.ft., then the 40-sq.ft. unit must have 25 per cent. additional surface to condense all the steam the valve will supply when turned on full. Most of the patented systems of vapor heating employ special graduated valves and return traps (of the types already described under vacuum systems) and have special devices for air venting, boiler regulation and for returning the water of condensation against the boiler pressure when the system is operating under pressure.

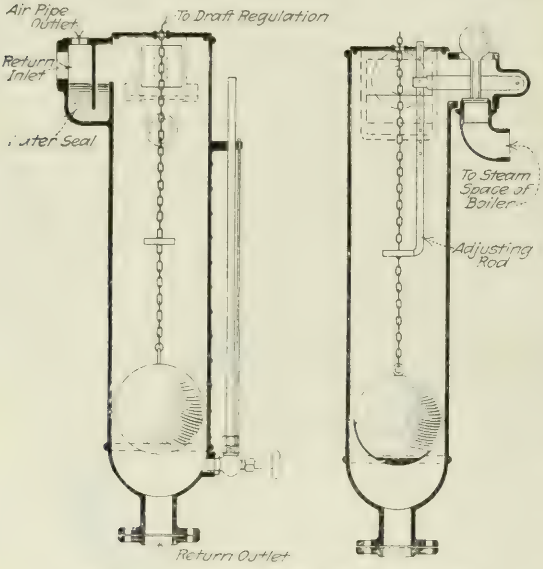


FIG. 4. RECEIVER FOR AIR VENTING

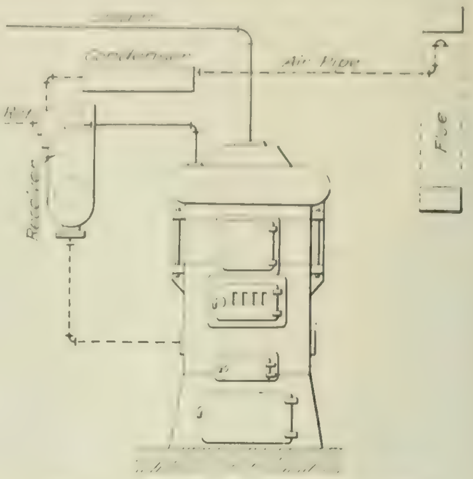


FIG. 5. PIPING OF VAPOR CONDENSER

In the system known as the "Adsco" an open return is used together with piping somewhat along the lines of that shown in Fig. 1 excepting that a special means of damper regulation is used. A graduated valve is arranged to give a different quantity of steam for each 5 sq.ft. change in the radiation and opens and closes with a three-quarter turn of the handle. On the return end no special trap or fitting is used, simply a union elbow, and in order to prevent steam blowing out into the return line the inlet valve is designed to supply only sufficient vapor to heat 80 per cent. of the radiator. This means that the radiator surface is some 20 per cent. greater than would be required if all the surface was active. The most distinctive feature of this system, however, is the boiler control, which is by means of a special regulator connected as shown in Fig. 2. The regulator itself consists of a cast-iron chamber, with a dial and pointer on the front as shown, inside of which there is a float which rises and falls as the water from the boiler backs up in the returns. This controller is connected to the damper chains and can be made to regulate the draft and fire so as to produce any pressure desired determined by the setting of the regulator.

Another vapor system, called the "Broomell" employs the so-called "Quintuple" valve and is an open-return system. It involves, however, the use of a special tapped elbow, Fig. 3, on the radiator return with a water seal of sufficient depth to prevent the vapor, at the very slight pressure maintained, from passing through, while a little hole in the partition permits a small but constant venting of air from the radiator into the return line. This answers in a very simple manner the purpose of a trap by the use of the water seal. In this system, however, the most distinctive feature is the receiver and method of air venting. The return line, carrying air and water, instead of being connected directly to the air vent and boiler, is run to a receiver, two sectional views of which are shown in Fig. 4. This receiver consists of a hollow cylinder inside of which is a float connected to damper chains, the operation being similar to the regulator already described; but owing to its peculiar construction, it does more than control the dampers by the float rising as the water backs up from the boiler into the receiver. At the opening marked "Return Inlet" there is a water seal, but there is no hole in the partition, as there is in the water seal at the radiators, for the air to pass through; instead, it finds its way out through the opening marked "Air-Pipe Outlet" to a condenser, usually hung on the basement ceiling, thence to the chimney or stack, as shown in Fig. 5. Any vapor that may be mixed with the escaping air is condensed in this condenser. The outlet of the condenser is run to a chimney flue and opened inside of the flue, so that whatever chimney draft there may be will assist in drawing out the air.

The receiver performs another function also. On the side of the receiver and set at 90 deg. with the inlet is an opening which is connected to the steam space of the boiler, but the vapor is prevented from flowing through by a weighted valve. If any unusual pressure is generated in the boiler, the float rises far enough to strike the lower end of the adjusting rod opening the valve, which may properly be considered a safety valve, thereby relieving the boiler pressure by allowing the excess vapor to escape. The water in the receiver (owing to the reduced pressure) then sinks down and the valve closes ready to repeat the cycle. The return water flowing into the receiver finds its way back to the boiler through the bottom opening marked "return outlet." Thus it can be seen that this receiver is really a combined air relief, damper regulator and safety valve.

The Hutchinson is also an open-return system employing a modulating valve on the radiator inlet and a simple union elbow on the outlet. The radiator surface is about 20 per cent. greater than the modulated valve is expected to supply to prevent vapor getting into the returns, and the air vent is taken off the top of the return somewhat similar to the method illustrated in Fig. 1, but between this vent and the boiler there is a unique device which controls the draft by means of a hollow sphere mounted at the end of a flexible connection pipe. When the vapor pressure is low, the hollow bulb is partly or entirely empty and is pulled into the upper position by the spring attached to the draft chain. As soon as the vapor pressure is sufficient, it forces the water in the receiver back into the water seal on the return until it reaches the branch pipe running horizontally out to the bulb. The water enters the bulb, increasing the weight, and causing it to overcome the spring tension, thus operating the draft-regulating chains. The various connections are shown diagrammatically in Fig. 6. The small pipe connected from the top of the bulb to the return main is a balance pipe which allows the free flow of water into and out of the bulb. The receiver also has a balance pipe, so that the water in the boiler connection really does not rise up into the receiver, but instead, the boiler pressure is applied on top of the water in the receiver, and forces the receiver water back through the water seal so that it is the receiver and seal water which really floods the bulb. If the bottom door is left open, however, and the movement of the bulb fails to check the increase in pressure, a more or less dangerous condition develops. The vapor pressure continues to increase in the receiver, blows out through the water seal and back into the return line, from which it is relieved by the air vent to the outer air.

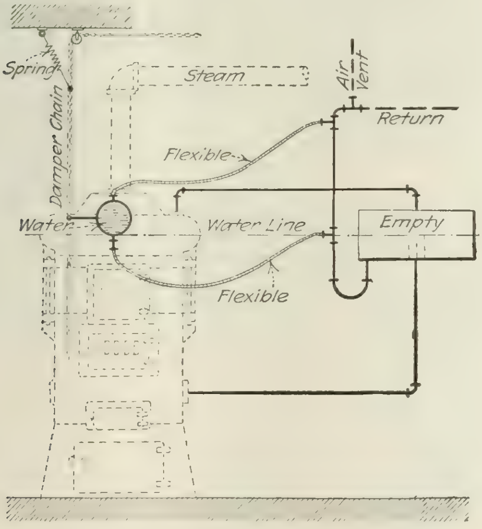


FIG. 6. DRAFT-CONTROL CONNECTIONS

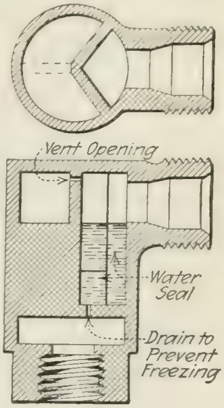


FIG. 7. SPECIAL RETURN FITTING

The Mouatt vapor heating system is another patented arrangement with an open return. The radiation is increased like the other open-return systems and a graduating valve is used on the radiator supply. On the radiator return connection a special return fitting is used, its construction being shown in cross-section in Fig. 7. The condensation comes back in the return main, which is air-vented where the line drops down to enter the boiler, and a check valve is placed close to the boiler tapping. The air vent itself is terminated in a chimney flue so that the chimney draft will help draw the air out of the system. The return in this system is in no way connected to the damper regulator.

The regulator deserves a brief description, since on its operation depends the success of the whole system. The regulator, as shown in Fig. 8, consists of a cylindrical tank *A*, mounted on a lever *B* which is counterbalanced by a weight on the other end. When the tank fills with water it outweighs the counterweight and falls, operating the draft chains. This lever is supported on a pivot pin on a small receiver, which is filled with water through a filling plug. A vapor pressure pipe is connected from the top of this receiver to the steam space of the boiler, and an overflow pipe is also provided so that any excess water will flow back to the boiler. Upon the vapor pressure increasing, the water in the receiver is forced out through the bottom opening into the flexible connection running to the lever arm and finds its way into the tank *A*, causing it to close the draft as described. When the pressure has been reduced a few ounces, the water runs back into the receiver and the tank is lifted by the counterweight, again opening the drafts.

The Moline system uses an open return, but incorporates a key-operated valve thereon so as to permit the cutting off of any radiator by the simple closing of the graduated valve used on the radiator supply and the lock shield valve on the return. In other respects the system does not follow the lines of those previously described. The return line has a seal, and a positive vacuum is maintained in it by a steam ejector, so that expelling air from the system is promptly accomplished; and after the air is once expelled, its reëntrance is prevented, so that the system continues to operate under a vacuum of greater or lesser degree until inleakage destroys the vacuum.

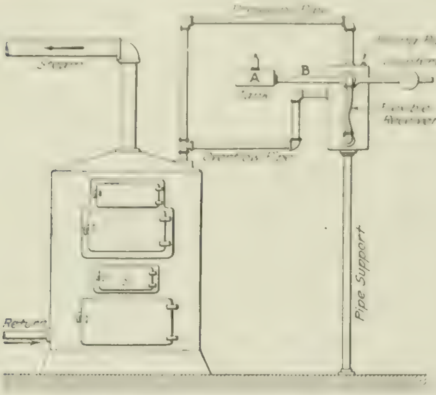


FIG. 8. REGULATOR AND PIPING

The details are as follows: The return line is carried back to a point near the boiler as usual and is cross-connected with the return, or bleeder, end of the steam main, which is also brought back as in a one-pipe circuit system; this cross-connection is made as illustrated in Fig. 9, with the ejector tee fitting arranged so that the blowing of steam or air through the fitting will produce a suction on the return line, thus drawing the air and vapor out of the return and accelerating the flow through the radiators. As the steam opening in the ejector fitting is small, only a small amount of steam is included in the mixture of air and vapor discharged by the ejector; this discharge passes into a small coil of pipe which serves as a condenser, where the vapor is reduced to water and finds its way back to the boiler through a drip at the end of the condenser. The air itself is relieved through a large air valve at the end of the condenser loop, with which is combined a vacuum valve which prevents the reëntrance of air at this point. The damper regulator is of sensitive type, but is in no way connected with the piping system. This regulator is connected directly to the boiler in much the same manner as the ordinary boiler regulator, simply controlling the dampers according to the pressure to a fine degree.

When this system is started, a slight steam pressure is necessary in order to blow the air out of the steam main through the ejector tee. This action at once starts the suction on the radiator return line so that the steam rapidly fills the radiators to the degree permitted by the position of the supply valve and progresses down the return, driving the air ahead of it and finally reaching the ejector tee. The vapor or steam following the air soon fills the condenser, and being much more than the condenser can handle, the steam and vapor pass through this coil of pipe and strike the air trap, which closes against any further flow. At this time the system has been entirely rid of air, and if the fire is allowed to go down the condensation of the steam in the system at once tends to produce a high degree of vacuum and the lower the fire the more nearly perfect this vacuum becomes. Because there is practically no air in the system, the vapor fills the entire system and keeps all the radiators hot. After considerable air has leaked in through various small openings and the vacuum is reduced, it is then necessary to generate a little steam pressure for the purpose of again blowing out the system. The periods between blowing out, however, are usually more than 24 hours, so that starting the fire each morning (or at the most morning and evening) is sufficient to maintain a good degree of vacuum at all times.

With the systems using the closed return may be classed the Webster modulation system. This uses graduating valves on the supply and thermostatic traps or valves on the radiator returns. The chief advantages of the closed or trapped return are the more or less positive obstruction to vapor getting into the return line and the fact that it is unnecessary to increase the radiator surface over that actually required to do the heating, as in the case of the open-vent systems. The chief disadvantages to the employment of traps on radiator returns are increased cost and the danger of some foreign particle lodging on the seat, interfering with the operation of the valve. In the Webster system the return line is brought back and connected to the boiler through a check valve, but before dropping the return down below the level of the water line in the boiler, an automatic air trap is connected in. The function of this trap is to relieve the air from the system, and a check valve on the air-vent pipe prevents its reëntrance, so that the only way air may enter the system is through normal leakage.

The Marsh modulation vapor system is quite similar to the Webster as far as piping is concerned. The radiators are controlled by a graduated valve on the supply and a thermostatic trap on the return of a slightly different design. Where the return drops below the boiler water line, a rapid air vent or eliminator is used. This is really only an automatic air valve of large size operated by a thermostatic disk and an inverted cylinder float.

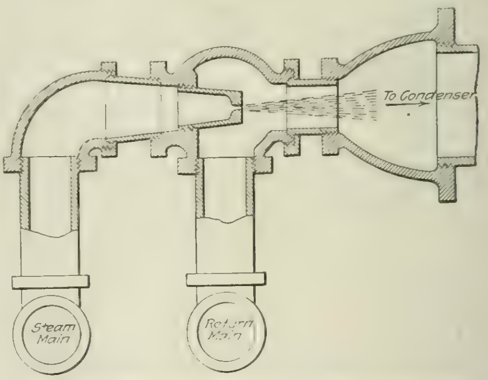


FIG. 9. EJECTOR FOR PRODUCING SUCTION

In so far as the operation of vapor systems is concerned, it has been the endeavor of all manufacturers to make them and the devices which go with them as nearly automatic as possible, so that the chief duty of the operating engineer is to keep his fires up and to know when his equipment is doing the work it should do. The most serious difficulty is teaching of the occupants of the various rooms to manipulate the radiator valve rather than to open the windows. For this reason most graduated valves are of the quick-opening type, giving all settings from closed to full open in less than one full turn of the spindle in order that it will be found easier to close the valve than it is to raise the window.

The foregoing covers in a general way the more common types of vapor heating systems, although there are many others more or less popular to which the same principles apply with slight modifications, so that further discussion is hardly necessary.

Heating Caused by Cracked Crankpin of Diesel Engine

By D. L. Fagnan

An early type of vertical three-cylinder Diesel engine had been operating for some years pretty well loaded, but giving the finest kind of service. It was a marvel to every mechanic who watched it work. Then suddenly it developed a hot crankpin on No. 2 cylinder. The engine was equipped with bronze bearings throughout, the main bearing being spotted with babbitt metal and plain bronze being used on the crankpin. The engineer had scraped and cleaned the brasses three times and was ready to swear that there was no cause for further heating. In fact, he had expended all his mechanical knowledge of how to fit a bearing of this kind, but apparently to no purpose. The crankpin bearing heated again and again and all the oil in the world could not keep it cool.

In despair, a telegram was sent to our company, and although we had not built the engine originally, I was sent to set things right. The engineer was a fine mechanic, and when I first looked at the engine I realized that I was up against the real thing.

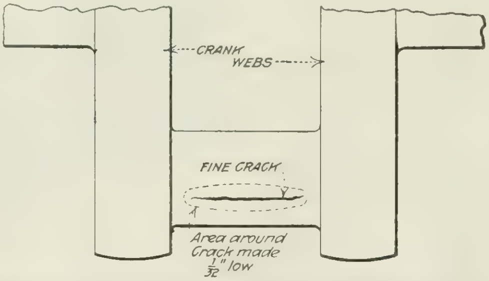
I lit my old pipe and examined the engine thoroughly, observing the cam setting on the cylinder whose piston was nearest dead-center position, and making a mental note that it looked about correct. I next examined the interior of the crankcase with a portable lamp. The oil seemed to be new and of good body and the interior of the case clean and orderly.

Next I calipered the crankpin in at least a hundred places and could detect very little variation from roundness—certainly not enough to bother about. The engineer watched my operations and volunteered the information that after the second scraping he had spent fourteen hours filing and truing up the crankpin, finally polishing it highly, and still the heating persisted. When he impatiently asked what I thought of that bearing, I answered that I had only begun to do some real thinking and that I would find the cause of the heating or else admit that Diesel-engine tricks were too much for me.

A magnifying glass or reading glass about three inches in diameter is always a part of my kit, being used principally to locate the railroad stations given in small print on Western maps. I used this glass on the crankpin, also a mirror to reflect light into the corners and angles, but I could detect no flaws or anything wrong. However, common sense told me that there must be something radically wrong with either the pin or the bearing, and possibly with both.

I had heard that after repeated heating a bronze bearing will lose some of its antifriction properties. So I reëxamined the brasses, testing the bearing surfaces in many spots with my small, sharp scraper to see whether any very hard spots existed. I tried each half of the bearing in the rod end to see whether there was any binding and found that each pushed home fairly easily, so that here at least was no chance for trouble.

Finally, I poured kerosene on the crankpin and rubbed some prussian blue on it, working this over the pin thoroughly by using a half shell. It showed a fine bearing and plenty of clearance where required. I then lighted a gasoline torch and approached the crank case, protecting my face and body in case there should be explosive gases present. Finding none, I gradually worked the torch up to the crankpin, poured more kerosene on the pin and heated this up with the torch until the pin could scarcely be touched with my bare hands. With a rag having prussian blue on it I rubbed the pin hard all over and then with clean cloths wiped it off. If there are any cracks or flaws in a piece of metal, this treatment will show them up.



LOCATION OF THE CRACK IN THE CRANKPIN AND THE AREA THAT WAS FILED DOWN

To my great joy, my glass showed dirty oil and prussian blue oozing out from a fine crack lengthwise of the pin, as shown in the illustration. Wiping it off twice did not blot it out. The engineer was jubilant, although he admitted he could hardly believe that a little crack like that could cause such a lot of trouble. The crack must have been of some depth, for after five wipings it still continued to ooze oil slowly. As it was lengthwise of the pin, we concluded that it did not weaken the pin greatly.

It was our opinion that the sharp edges of the crack working on the brasses when the engine was running caused heating by continually scraping off the lubricant and also by making a powder out of the brasses. So we decided to file the pin down until it was about $\frac{1}{32}$ in. low in the neighborhood of the crack, as indicated by the area outlined in the illustration, so that the pin surface at the crack could not touch the brasses again. We then assembled the engine and started it carefully. We ran it for four hours, feeling that crankpin bearing often, but not a sign of heating developed after the initial heating that always manifests itself when a new bearing is started.

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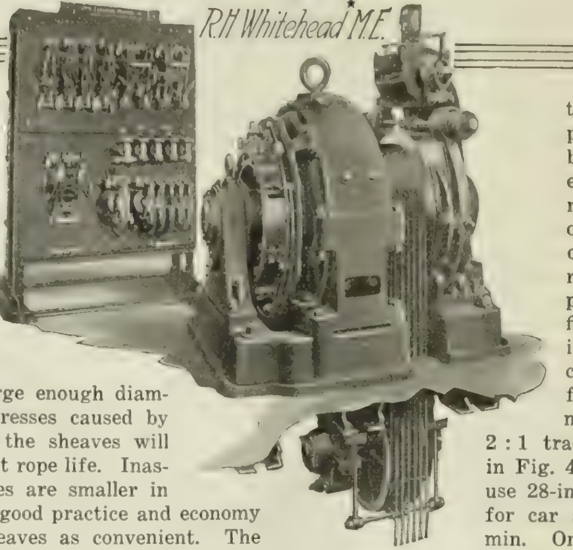
Geared and Gearless Traction Elevator Machines

By R. H. Whitehead[*] M.E.



IN THE traction type of elevator machine the car-hoisting ropes travel at the peripheral speed of the driving sheave, and the friction between the ropes and sheaves must give sufficient traction to care for all conditions of car loading without slippage. The driving sheaves used must be of large enough diameter so that the bending stresses caused by the ropes traveling around the sheaves will not be sufficient to cause short rope life. Inasmuch as the bending stresses are smaller in the larger size sheaves, it is good practice and economy to use as large-diameter sheaves as convenient. The maximum size of the driving sheave is limited by two factors: First, it must not exceed the span distance between car and counterweight centers (see Fig. 3); secondly, by the allowable speed of the driving sheave, since an increase in diameter with the same speed of rotation results in an increased car speed.

In the worm-geared type of traction machine as shown in Fig. 1, a high-speed motor is used, and the desired speed of the car is obtained by using the proper gear reduction. The motor speeds for this type of installation vary from 600 to 1200 r.p.m., depending on the motor's horsepower, the larger horsepowers being possible only at the slower speeds. In worm-geared-traction machines manufacturers endeavor to use as high-speed motors as possible compatible with good engineering practice. It is well known that for a given horsepower rating a slow-speed motor is larger than a high-speed one, which results in higher costs. The torque, or pull, of a high-speed motor is less than that of a slow-speed machine of the same horsepower. Therefore the size of brake, which is designed to hold full-load motor torque, the size of the wormwheel shaft, and in fact the entire machine is lighter when using a high-speed motor as compared with a slow-speed machine of like horsepower.

The size of the driving sheave on a worm-geared machine depends on the gear ratios available for the high-speed motors used with this type of machine, and the speed of the motors depends on the duty. It has been found that the diameter of sheaves for good rope service depends not only on the size and kind of rope, but also on the rope speed. It is general practice to use $\frac{5}{8}$-in. extra-flexible steel cables on 36-in. sheaves for traction machines with 1:1 roping for speeds of 600 ft. per min., roped as in Fig. 3. On 2:1 traction machines, roped as in Fig. 4, it is general practice to use 28-in. sheaves and $\frac{1}{2}$-in. cables for car speeds up to 450 ft. per min. On slower speed traction machines it is permissible to reduce the sheave diameter. In a number of installations, on the higher speeds, smaller-sized sheaves are used, but this results in shorter rope life for like operating conditions than with sheaves of standard sizes. Short rope life may also result from poor quality of ropes due to manufacturing conditions or to neglect in keeping all the hoisting ropes under equal tension. There is, however, a difference of opinion among engineers as to the proper diameter of sheave to use for various sizes of ropes under different conditions.

Summing up the preceding, in a worm-gear-traction installation the manufacturers of elevator machines use high-speed motors to keep down the cost and use sheaves as large as the worm-gearing reduction will permit without exceeding the span distance of car center to counterweight center. This limits the speed of the worm-gear-traction machine to 450 ft. per min. for loads up to 2500 lb., as it is possible to get only certain minimum worm-gear reductions. For instance on this duty the motor's speed would be 600 r.p.m. With 1:1 traction $\frac{5}{8}$-in. ropes would be used on minimum-sized sheaves, of 30-in. diameter, for good rope service at this speed. The driving sheave would rotate

$$\text{at } 450 \div \frac{30 \times 3.1416}{12} = 57.4 \text{ r.p.m.}$$

With a 600-r.p.m. motor the gearing reduction would be about 10 to 1. This is about the limit of worm-gear reduction for elevator machines, although a 12-thread worm has been

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[*] Engineer with Geo. W. Goethals & Co., Inc.

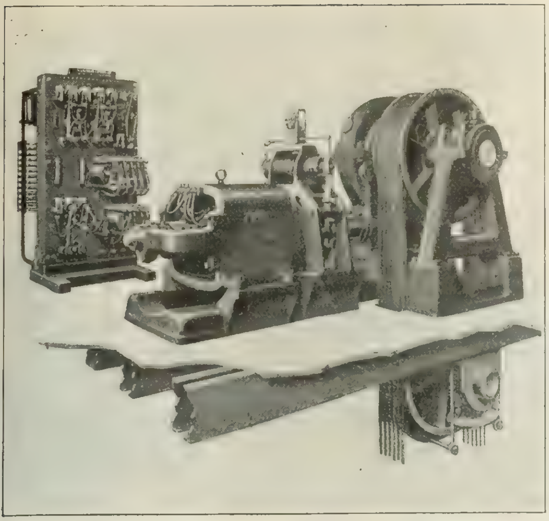

FIG. 1. WORM-GEAR TYPE TRACTION-ELEVATOR MACHINE

used with a 108-tooth gear wheel giving a speed reduction of 9:1. It is obvious that it is not practical to build worm-geared-traction machines for speeds in excess of 450 r.p.m., and this speed presents difficulties in manufacturing on account of the large number of threads on the worm. The worm-geared-traction machine is most suitable for speeds up to 350 ft. per min., and where a speed of 450 ft. per min. is desired either herringbone-gear reduction machines or the 2:1 gearless-traction machine is preferable.

Elimination of the worm and gear results in smoother operation and quicker acceleration. The gearless-traction machine shown in the headpiece and in Fig. 2 uses a driving sheave and brake wheel attached directly to the motor shaft. Inasmuch as the dimensions of a motor for a given horsepower increase as the speed decreases, gearless-traction elevator motors are very large for their horsepower rating. A standard 60-r.p.m. motor rated at 38 hp. is several times larger and more costly than the same size motor of 600 r.p.m. used on the worm-geared-traction machine. The brakes are also larger and more costly since the torque of a 60-r.p.m. motor is ten times as much as the torque of a 600-r.p.m. one of like horsepower. In general the gearless-traction elevator motor used on the 2:1 installations, as shown in Fig. 2, has about twice the speed of the motor used on the 1:1 installation, shown in the headpiece, and is consequently much lighter in weight.

As the driving sheave rotates at the motor's speed, on the gearless-traction machine, this machine is in general practical for installations requiring high car speeds, from 450 to 700 r.p.m. This range of speed is in general required only in very tall buildings, with the exception that an installation of this character is sometimes used in medium-height buildings, such as department stores, to obtain the advantages of the smooth operation and quick accelerating characteristics of this type of machine.

For 2:1 installations roped as in Fig. 4, ½-in. ropes are generally used on 28-in. sheaves. For a 450-ft.-per-min. car speed the driving sheave and motor must rotate at $450 \div \frac{28 \times 3.1416}{12 \times 2} = 122$ r.p.m. Slower speeds than 450 ft. per min. are sometimes obtained by the use of smaller sheaves than 28-in. but experience has shown that this will result in short rope life. In the 2:1 type of installation the ropes travel at twice the car speed and around two more sheaves, one on the counterweight and one on the car, than in the 1:1 type. The rope life in this type of installation is liable to comparatively short life, caused by the ropes traveling around so many sheaves at high speed. This disadvantage may be outweighed where heavy traffic from floor to floor requires quick acceleration for rapid traveling.

The 1:1 gearless-traction machine is used only with high car speeds and high rises, from 300 ft. up. The usual installation has a 36-in. sheave and uses ⅝-in. ropes. A 36-in. sheave driven by a 60-r.p.m. motor gives a car speed of 570 ft. per min. Elevators of this type give good rope service and are built for speeds up to 700 ft. per min., which is the maximum allowed by law in New York City. For a 2500-lb. carload at 600 ft. per min. the motor has a rating of 38 horsepower.

Certain installations require the application of a gearless-traction motor of the very slow-speed type to a comparatively slow-speed installation, as the amount of power that can be transmitted by a worm and gear is limited to approximately 50 hp. There is no limit to the amount of power that can be applied to a gearless-traction elevator, except the space requirements for the machine. In the New York subways at certain stations lifts are provided from the train platforms to the street levels capable of handling 11,000 lb. at 350 ft. per min., using gearless-traction elevators roped 2:1.

In Fig. 5 is shown the roping of a V-groove traction-elevator machine. This type of drive is now under test with gearless-traction machines to determine the relative life of ropes as compared to the standard type using a secondary sheave.

In the case of the standard type the ropes make two half-turns around the driving sheave and one half-turn around the secondary sheave, as compared to one half-turn on the driving sheave of the V-groove type. The pinching effect of the V-grooves on the ropes may,

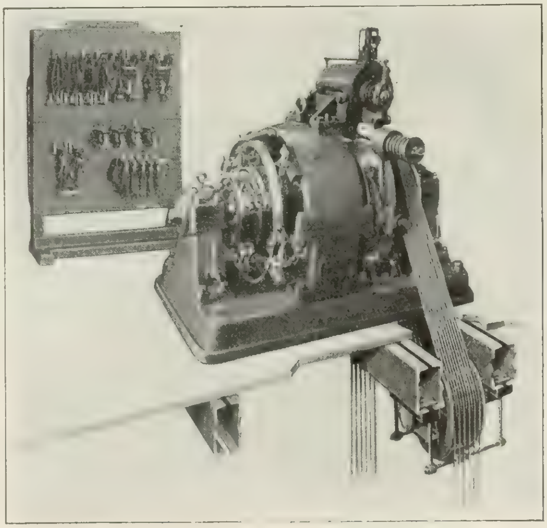

FIG. 2. GEARLESS TRACTION MACHINE ROPED 2:1

however, cause more wear than the two extra half turns. Another question is the wearing of the V grooves by the ropes, wearing of these grooves would result in loss of traction, and if the sheaves had to be replaced or recut frequently, this would be more objectionable than installing new ropes. The writer believes, however, that the V groove gearless traction elevator is a strong possibility of the future, as the machine can be built at lower costs than the standard type, owing to the downward pull on the driving sheave being only one-half that in the latter type. This results in a lighter sheave, a smaller-diameter armature shaft and bearings, smaller supports and lighter frame, and the secondary sheaves, with their bearings, supports, etc., are eliminated. In cases, however, where the V-grooved sheave does not span the distance from center of car to center of counterweight an idler sheave must be provided to lead off the ropes properly. This sheave can be of light construction compared to that of a secondary sheave in an equivalent standard installation.

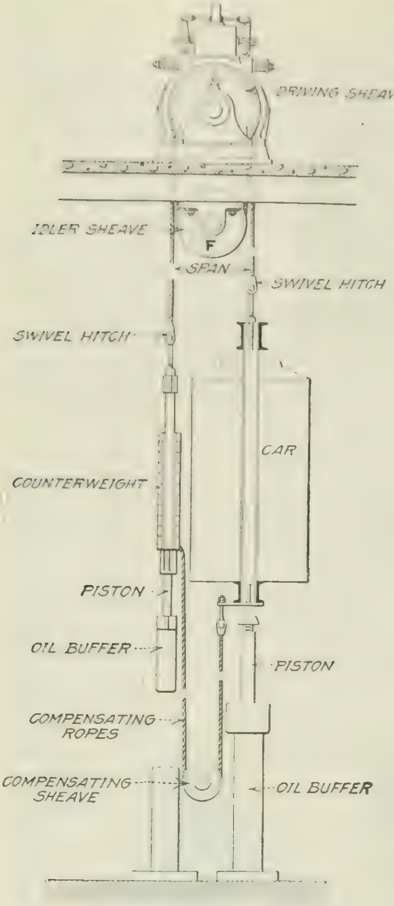

FIG. 3. DIRECT-TRACTION ELEVATOR MACHINE, 1:1 ROPING

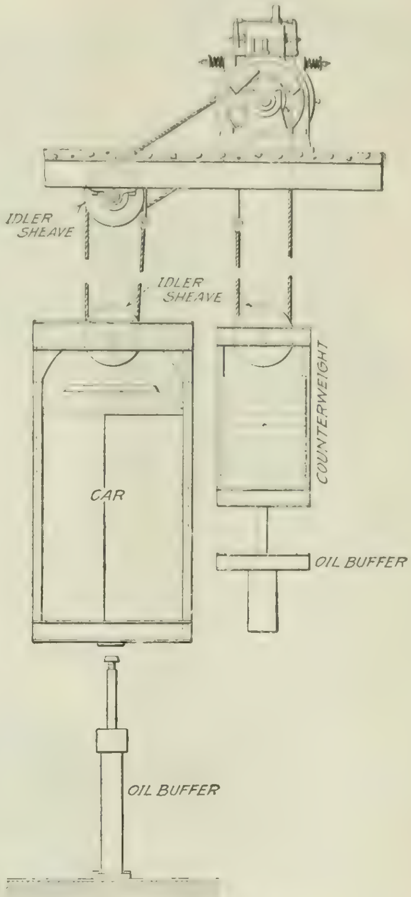

FIG. 4. DIRECT-TRACTION ELEVATOR MACHINE, 2:1 ROPING

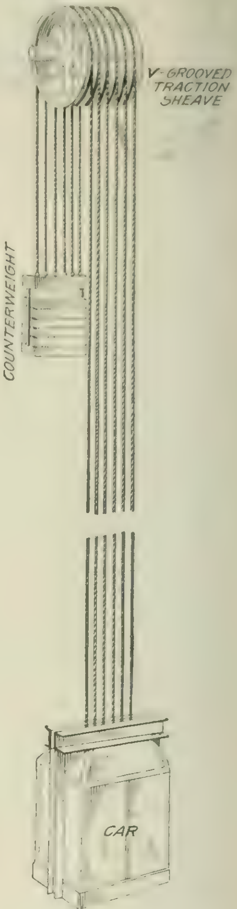

FIG. 5. V-GROOVED TRACTION ELEVATOR MACHINE

The gearless-traction elevator has been developed to date for direct-current motor drive only. It is possible to build alternating-current motors to drive direct-traction elevators, but this has not been done because modern buildings requiring 550 to 700 ft. per min. car speed are all users of direct current.

Some modern buildings of medium height use alternating current, but all their requirements to date have been met with geared-traction elevators. Alternating-current direct-traction mine hoists have been built and put in operation, and when there is a demand for the alternating-current gearless type traction-elevator machine we may expect to see it supplied.

Duty To Warn Employee

Where a tar-boiling tank was connected with a high-pressure steam boiler for use in the process of melting the tar and there was a relief valve in the head of the tank, the owner is liable for injury to an employee while at work at the tank, resulting from the employer's negligence in failing either to see that the valve was open when live steam was being forced into the tank, or to warn the employee against the danger, which was unknown to him.

The injury resulted from overpressure of steam in the tank, causing the head to be forced off suddenly. (Iowa Supreme Court, Garren vs. Ottumwa Gas Co., 170 Northwestern Reporter, 428.)

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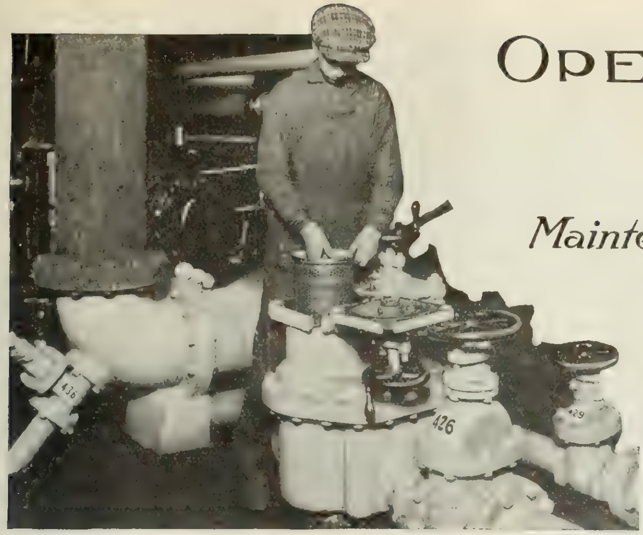


OPERATION AT HOLTWOOD

Maintenance of the Governor Control System

By
Charles H. Bromley

The fluid for actuating the governor-operating mechanism consists of filtered water, soluble oil and barium hydrate; its normal pressure is 275 lb. Many provisions are made against loss of the fluid pressure. Cooling coils in the governor-fluid reservoirs are cleaned every three months. Tanks and piping tested to 500 lb. to reveal weaknesses caused by corrosion. Extra-heavy galvanized pipe and gate valves with bronze parts are used.

THE pressure fluid for operating the governing mechanism is handled by a central pumping plant. The piping in this system is all extra-heavy steel, and all valves are extra-heavy and of the gate type. Formerly, the gates, toggles, yokes and stems of these valves were of cast iron; but bronze is now used, which obviates corrosion troubles. New extensions and replacements to the piping are made with galvanized pipe.

The fluid consists of filtered water with a certain admixture of barium hydrate and soluble oil. To each 250 gal. of filtered water one pound of barium hydrate is added and thoroughly mixed. This solution must stand eighty hours before it is admitted to the system—that is, to the sump tank. The barium hydrate acts as a neutralizing agent against the corrosive action of the river water. To give the solution lubricating properties 10 gal. of soluble oil to 30 gal. of filtered water are mixed and 2 gal. of this lubricant, or emulsion, is admitted daily to the sump tank, there being little leakage. A 30,000-gal. concrete tank on the stop-log gallery is used for mixing the barium solution.

The alkalinity of the fluid is tested daily by the hydraulic floorman, with phenolphthalein solution, which is a simple procedure, taking only a few minutes; he is seen doing this in Fig. 2. Several drops of the phenolphthalein are let into the test tube containing the fluid; if the fluid is slightly alkaline and not acid, the chemical turns it pink. A fluid that is just neutral may not be noncorrosive. Where the solution is very dilute, the dissolved salts may be so dissociated as to start and maintain the progress or corrosion. The carbon dioxide or the sulphuric-acid radical, or both, attacking the metal, combine with it, then separate, then attack again, the cycle being continuous. To avoid this action the aim is to maintain an excess of barium hydrate in the fluid.

F. W. Wood, of the Maryland Steel Co., diagnosed the corrosion troubles at Holtwood, and the engineers there are grateful to him for his investigations and the remedial measure suggested.

The sump tanks are the main reservoirs for the governor fluid and are kept nearly half-filled with fluid; the other half, or 60 per cent. to be exact, is filled with air. The pressure normally maintained on the fluid is 275 lb. per sq.in. The tanks have cooling coils through which cold water circulates to keep down the temperature of the fluid. These coils are drained and cleaned with air and water every three months, or oftener if indications show that they are covered with sludge.

While there is no definite time for testing the central pumping system for the governor-control mechanism, at least once every two years the piping, tanks, etc., are tested to 500 lb. hydrostatic pressure to detect fittings

FIG. 1 THE TAILRACE AT HOLTWOOD

and pipe weakened by corrosion. This test is usually given during the low flow season, when a portion of the station is shut down for several hours in the morning. The system is sectionalized for this test and the air removed from the accumulator tanks under test to minimize the danger of explosion. The pressure is built up by a hand-operated pump.

As may be seen from the headpiece, the valves in the system are plainly numbered. The piping must of course be kept clear of sediment, sludge, scale, etc. The extent to which the sump tanks have sludge, scale, etc., deposited in them indicates how seriously the headers and piping may be affected. The deposit of sediment in the accumulator tanks gives one an idea of the condition of the headers. This is also apparent when the pumpman attends to the routine cleaning of the twin strainers in the suction line between sump tank and governor pumps. For supplying water for cleaning, the 300-hp. pump is used and only one section is cleaned at a time.

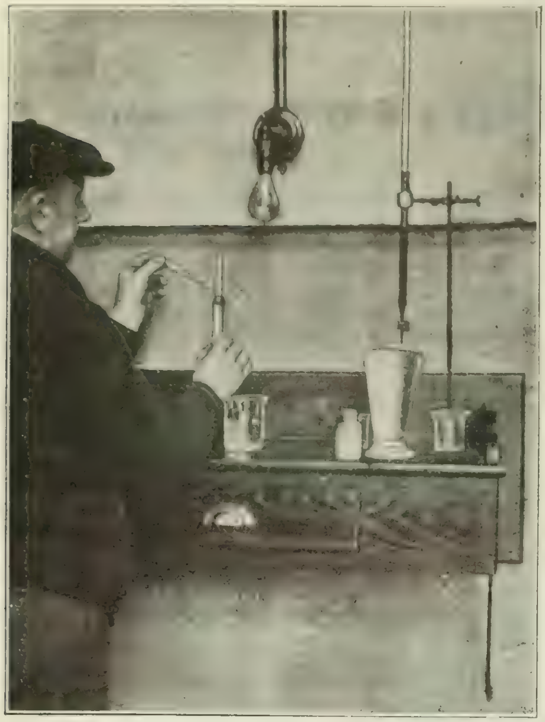


FIG. 2. HYDRAULIC FOREMAN MAKING DAILY TEST OF GOVERNOR-PRESSURE FLUID, DETERMINING ALKALINITY WITH PHENOLPHTHALEIN

To clean headers and piping, the valves in the balance pipe to the governor and hand control are closed, the governor pilot and regulating valves removed, and a tapered wooden plug driven into the valve side of the head cover. The valve chamber is closed by bolting the head cover to the chamber. This is to prevent the escape of fluid. The two valves on the accumulator tanks are now opened. The units dependent upon this part of the system for governor-operating pressure are operated by hand control—entirely separate from the governor-control system—if it is desirable to keep them in service during this cleaning period; the governor-header section valve is closed and the governor return-header valve to No. 1 governor sump tank opened. A governor pump is now started and the greatest possible quantity of water circulated for about ten minutes. If there is much sludge or sediment, the fluid in the sump tank will be discolored, turning from a milky to a brick color. The sump tank is next drained and flushed.

Close examination of the governor-regulating valve is made for scale, etc., before replacing it. As scale may be loose and washing about, the governor-regulating valve is carefully watched for some time after cleaning. The scale usually finds its way to the sump tank. Once every three months the check valves on the accumulator tanks are lubricated with waterproof graphite grease.

[Record forms, filled out by the chief machinist and kept in the office of the chief operator, tell at a glance when the system was inspected, what was done and by whom. These forms, together with the many others used at Holtwood, are the subject of an article on record keeping and follow-ups which will appear a few weeks later. An article to follow this present one on operation at Holtwood, which will appear soon, tells of the thorough way in which the submerged pins of the governor-operating mechanism are lubricated, and how the corrosion and rapid wear of these pins have been reduced to a negligible minimum.—Editor.]

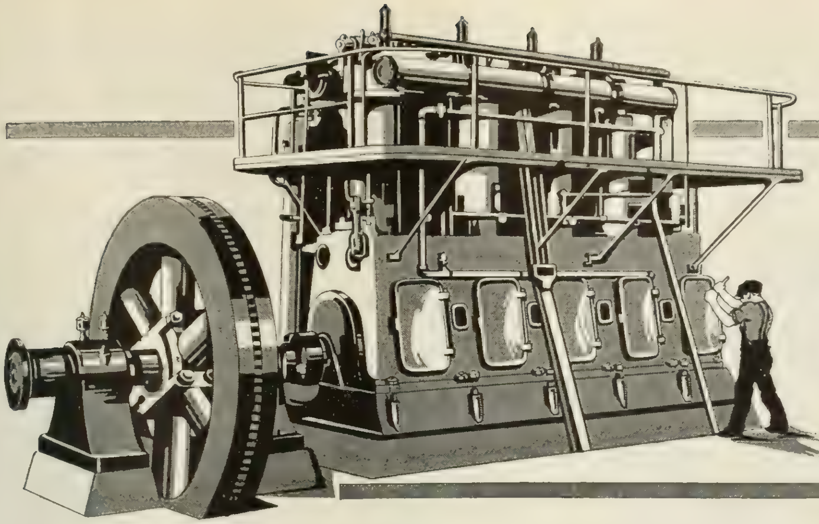
Improper Fusing of Circuit Caused Motor To Burn Out

By E. C. Parham

The main auxiliaries of a motor-driven feeder voltage-regulator equipment are the contact-making voltmeter and the relay switch. The voltmeter includes the contact-making parts of a direct-current generator voltage regulator. If the voltage varies a small percentage above or below standard, the voltmeter needle makes a contact that energizes one of the two operating coils of the relay switch, causing that switch to establish the proper circuit for rotating the motor in the right direction. The current handled by the contact-making voltmeter is very small, where that in the relay switch may be very appreciable if the motor or the regulator is out of order. As the pendulum contacts of the relay switch are spring-supported and as current passing through a spring tends to draw its temper, the springs of relay switches have soft-copper shunts connected in parallel with them.

A feeder regulator the frequency of operation of which had been gradually increasing for some time, began to blow fuses. At first the operator replaced the fuses with similar ones, but the blowings got to be so annoying that heavier ones were installed and finally, to avoid buying fuses, copper wire was wound around the fuse clips. The next stage of the progressive destruction was burning of shunts, contacts and springs, and it was at this stage that a complaint was made that the regulator "was not working right." An inspection, which then was about a year late, disclosed that the stator winding of the regulator motor was burned almost to a crisp and that there was no relief excepting to rewind it or get another one.

Occasional blowing of a fuse may be no reason for alarm; the fuse may have been defective or it may have been carelessly installed. Frequent blowing of apparently standard fuses, however, calls for an investigation.



Talks on DIESEL Engines

by L. H. Morrison

XVI—*During the week the company had been conducting tests of fuel oil, preparatory to awarding the year's fuel-oil contract. So the men were prepared to hear a discussion of oil at the evening meeting.*

"WHY do our three makes of engines act so different with the very same oil?" It was Kelly who fired this opening gun.

"Because the results obtained depend a great deal on the engine," said Egan. "If the oil is a little heavy, the compression will affect the combustion. If the compression pressure, and consequently the temperature, is low there isn't enough heat in the combustion chamber to ignite the oil thoroughly and the exhaust will be smoky because of unburnt carbon passing into the exhaust. Another evidence of the poor combustion will be the decreased horsepower. As to the high compression necessary to secure proper combustion of the heavier oils, it is well to bear in mind that this requires a higher injection pressure."

"Why so, chief?" asked Kelly, who was trying out one of Egan's cigars and was devoting most of his attention to that piece of "rope."

"A little exercise of your gray matter would prevent that question," retorted J. R., who rather objected to Kelly's cigar confiscation habits. "Can't you see that if the pressure in the cylinder is high, the air pressure must also be high to have the same pressure drop through the atomizer? If heavy oil is to be used, of course, the engine compression can be increased by inserting shims between the connecting-rod and the big end. But even with the compression high enough to burn this heavy oil, you must raise your injection pressure anyway. Before Kelly asks why, I'll say that the heavy oil has greater frictional resistance going through the atomizer, and a higher air pressure must be used."

"Well, chief," began Woods, "what kind of fuel oil do you recommend? I've just read a catalog, and it looks like that engine can burn any oil."

"Yes, I've read those catalogs, and they claim to burn anything from anthracite to buttermilk. But there is a lower limit as well as a higher limit to the gravity of oil that can be used continuously. I can take any oil that will flow through an inch pipe and make our engines handle it for a day; but I won't state definitely the length of time the engines will be down for cleaning the cylinders and loosening up the rings. The desirable oil is one that will burn clean, with no carbon deposits."

"How about kerosene, then, chief?"

"That is a reminder, Woods, of your old days of running a hot-ball engine. Kerosene is the thing in such a mill. With a Diesel engine it is too light and volatile. Even if the fuel-valve cage is water-cooled, it is pretty warm down close to the nozzle, and a good deal of the kerosene will vaporize. This is especially the case with an open nozzle. When the needle valve opens, the air pressure blows this gas into the cylinder without any 'braking' effect. We then have the ignition of a considerable mass of fuel gas, which will cause a knock or preignition pound. The engine has a tendency to run hot. This, of course, is due to the fact that most of the kerosene is injected at or before dead-center, which means less power production and more heat absorbed by the engine itself.

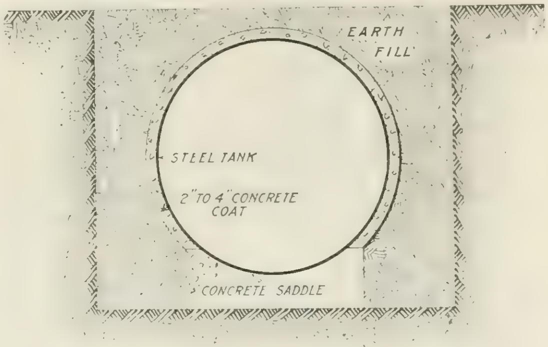


FIG. 1. PROTECTING A BURIED STEEL STORAGE TANK

In the next article the chief will describe various methods of cooling, forms of cooling towers and troubles that are caused by scale

"The same objection applies to the oil that is popularly known as distillate, having a gravity of from 36 to 44 deg. Baumé. I've found we have had more luck with the distillate known as desulphurized fuel oil. This has a gravity from 28 to 34 deg. Baumé, and while black in color, is clean and practically free from grit. It flows fairly freely, which is a boon in winter when the heavier oils are practically useless unless heating coils are used in the storage tank."

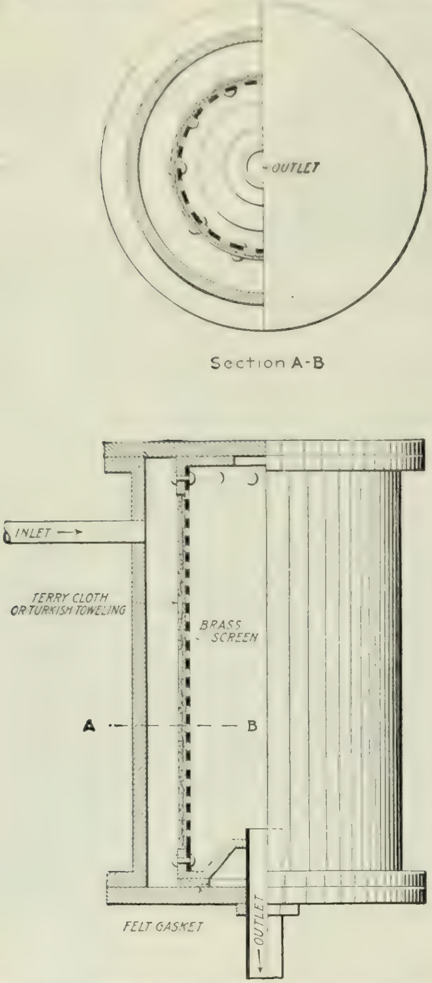


FIG. 2. HOME-MADE FILTER FOR FUEL OIL

"What oil showed up best in the tests, chief?" Kelly inquired.

"The 28- to 34-deg. oil burned better, the exhaust showed clearer, and after a ten-hours' run the cylinders were clean, and the valves free from carbon. It will cost more per gallon than the 20-deg. oil that we tested the first day, but the amount used per year will be less and our repairs lots easier."

"How about that 'slop' which came from Mexico? I didn't fancy that when we ran it out of the barrels." It was Kelly that relieved himself of this caustic opinion regarding the fuel from our southern neighbor.

"Your taste, Kelly, for once was very good. I confess I was attracted by that cheap oil. I'd heard of several plants using it. We wrote to one plant, asking their experience, and the reply was favorable. During these tests I learned from the oil man that this identical plant was having trouble. It's strange how people always write good letters about a thing that they have been cussing ever since they had it. I remember the first gas engine I ever ran. It was about the worst piece of cast iron that ever had flywheels on it. But whenever anyone dropped in to investigate that make, I'd praise it to the skies, though I knew I was a liar. I don't know if it's because we want to be kind even to things we feel like damning or whether it's a desire to see another sucker bite. That is why I never care much for letters of recommendation."

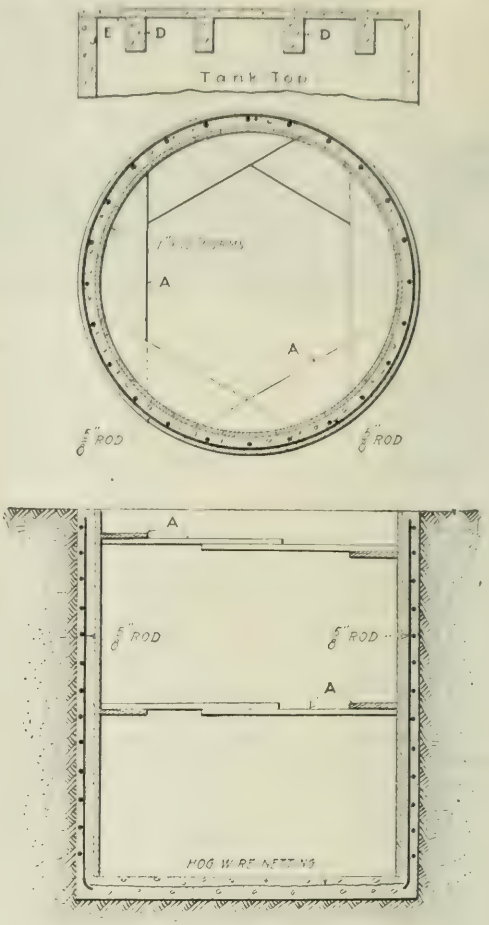


FIG. 3. CONSTRUCTION OF CONCRETE STORAGE TANK

"But what about that oil?" Kelly did not intend that his question should go unanswered.

"The trouble with that 14-deg. oil is that it gums up the engine. You know how much work we had cleaning the piston heads and loosening up the rings. Such an oil wouldn't do where an engine was to be fully loaded for hours at a time. It has no place in an engine unless used in connection with an ignition oil."

"What oil?" Woods was quick to inquire.

"In a minute, Woods, we'll look into what I mean by ignition oil. I believe you fellows should know what oil we'll use this year. Here are the specifications: Heat value, not less than 18,500 B.t.u. per lb.; gravity at 60 deg. F., from 28 to 34 deg. Baumé; residue, not over 10 per cent. after a sample has been heated in an oven for 100 hours at 550 deg. F.; flash point, 160 to 220 deg. F.; burning point, 180 to 275 deg. F.; sulphur, not over 0.5 per cent.; water, not over 0.25 per cent.; and the oil to have an asphaltum base.

"There should be a filter between the storage tank and the engine tank. We use the home-made kind shown in Fig. 2. As you see, the top and the inside screen can be removed for cleaning without breaking a single pipe joint. By the use of two filters, one can always be at work. There is but one feature that requires care. Always be sure that the felt packing rings are in place when you insert the screen. This screen is made of perforated brass sheet and is covered with two folds or layers of terry cloth, although we are actually using Turkish toweling, since we have no real terry cloth."

"Mr. Egan, what sort of storage tank is the best?" Woods questioned, since it was evident Egan was through with his filter.

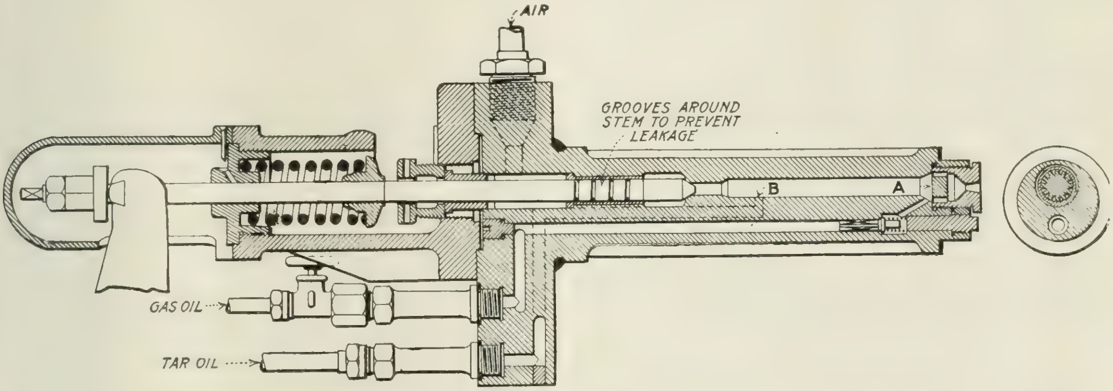


FIG. 4. SECTIONAL VIEW OF KOERTING NOZZLE FOR GAS OIL AND TAR OIL

"If a plant is under 500 hp. a steel tank is best, I think. It is more expensive than a concrete tank, but the ordinary concrete man cannot build a leakproof tank. The size required will not justify securing an expert, and so the steel tank is the best to use."

"How about a wood tank?"

"A wood tank has one thing attractive about it—its low cost. But the low cost proves expensive in a year's time, owing to the rapid evaporation of the oil. No matter how low grade it is, there are some lighter portions, and the hot sun seems to draw these through the wood staves. I'd estimate a loss of at least 10 per cent.

"As to the steel tank, it doesn't pay to use too light a plate. The shell should be of $\frac{3}{16}$- or $\frac{1}{4}$-in. material and the heads should be $\frac{1}{4}$ in. thick. The longitudinal seams should be double-riveted, but the girth seams may be single-riveted. If a capacity of 8000 gal. is required, one tank will do, but for a greater capacity use two tanks. Then you have a chance to clean out the slime from one while the other is full."

"How about putting the tanks in the ground?" broke in Woods.

"By all means," said Egan. "If they are above ground, there is always a fire hazard, and the pipes are exposed to injury and meddling. Place them on concrete saddles in a pit about a foot deeper than the diameter of the tank, and pack earth in the pit, leaving about 4 in. between the dirt and the tank, as shown by the cross-section, Fig. 1. Then pour in concrete, covering the entire surface of the tank. If wooden forms are used, the concrete covering can be made as low as 2 in. thick. Of course, the concrete must be fairly neat to run through this narrow space. You then have a rust-proof storage.

"In making concrete tanks I favor the vertical cylindrical type. A good many square tanks have been built, but they all tend to crack at the corners. Some people say that if oil leaks into the surrounding dirt it will form a cement and prevent further leakage. The trouble is that a lot of oil is lost before this cement job is finished.

"It is easy to build a round concrete tank. Dig a circular pit of the necessary diameter and depth as shown in Fig. 3, and inside it build up a cylindrical form made of boards 1 in. by 12 in. held to shape by the segments *A*. Use hog wire netting to reinforce the bottom, insert the vertical reinforcing rods about 18 in. apart. and to them wire the circles, spaced about a foot apart. Then run in the concrete between the wooden form and the sides of the pit."

"How about the top?" asked the Scotsman.

"That's the hardest part," said Egan. "Some use a wooden roof, but we covered ours with concrete slabs supported by reinforced girders. Our tanks were 12 ft. in diameter and 16 ft. deep, and we used four girders *D*, each 8 in. by 12 in. cross-section. To make them we built a wooden form having that cross-section and inserted twelve 1-in. iron rods to reinforce the concrete. We ran the girders of different lengths, to suit their position on the tank. The slabs *E* were not reinforced, but were grouted together, and the job was very satisfactory."

"Chief, you spoke of 14-deg. oil needing heating coils in the tank. I notice that our tank has coils, even if we do use light oil."

"That's a thing all storage tanks should have. It makes the fuel easier to handle and no steam boiler is needed. There are two ways to operate the coils without a boiler. The first method is to operate the engine cooling-water system under pressure, or, as it is called, use a closed system. By arranging the necessary regulating valves, part of the discharge can be bypassed through the tank coils. It takes a good while to get the oil up to 120 deg. F., but once it is warm the coils will keep it up to this temperature. The second method is to arrange a jacket about part of the engine exhaust pipe. Connect this to the overhead water tank, using a check valve in the line. Run the other end to the coils, and then arrange to discharge the coils into the cooling-water sump. By cracking the regulating valve a slight amount a circulation of hot water is set up.

"If you ever put in an outfit, use a lot of pains with the oil piping. Every joint should be threaded carefully and made up without any red lead or other compound. Remember that oil will leak at joints that are watertight. Never use anything but heavy-pattern brass valves with nickel seats and valve disks.

"A very important adjunct to every Diesel plant is a starting tank of kerosene. Even with a good grade of fuel oil it's hard to start an engine on cold mornings. Using kerosene for the first five minutes will bring the engine up to speed quickly and warm up the combustion chamber and valves."

"Now, chief, what did you mean by ignition oil?" Woods inquired.

"Well, as I stated, low-grade oils, such as Mexican, ignite slowly. If an engine runs at 180 r.p.m., there are three revolutions per second. If the period of combustion is 10 per cent. of the piston stroke, it cannot exceed $\frac{1}{60}$ of a second. "When you recognize that the beginning of the injection of the fuel and its atomization are necessarily slow and consider the time spent in mixing the atomized fuel and the air, as well as the cooling effect of the injection air, it is evident that there are many factors that tend to retard the combustion. Even with a high-grade oil this period is none too long.

"Low-gravity oil demands a longer time in which to be atomized, mixed with the air charge and ignited. The oil particles are larger than in the case of light oils and the actual time of burning is longer. To allow a very low-grade petroleum oil or tar to be burned, one of several methods must be adopted. The first method is to heat the heavy oil or tar to a temperature around 200 deg. F. and to raise the injection-air temperature to avoid any chilling action during the atomization of the charge. This method is fairly satisfactory with oils above 16 deg. Baumé, but with lower grade oils and tar I've never heard of any plant using this successfully.

"The second method is a variation of the first. The oil is heated and a small amount of gas oil of from 25 to 35 deg. Baumé is mixed with it in the storage tank. It's practically impossible to keep the two oils thoroughly mixed without resorting to some form of mechanical agitator. In one plant a motor-driven paddle wheel such as is found in a brine-cooling tank was employed. The light oil thus added is called an ignition oil. Its purpose is to supply a fuel that will ignite quickly, raise the cylinder temperature and produce a flame. This plan works with any petroleum fuel, but is not very good when tar oil is used. In tests using mixtures of tar oil and gas oil it has been proved that 25 per cent. of tar oil and 75 per cent. of gas oil is the best mixture when the engine is to operate on a varying load. If the engine is to develop full load all the time, a 50-50 mixture can be used, because a high temperature is maintained. Consequently, it would be advisable to use gas oil for low and half loads, reserving the use of the tar mixture for three-quarters and full loads only.

"Another method involves the use of a small amount of gas or solar oil that is deposited close to the nozzle and blown into the combustion chamber ahead of the tar oil. The oil ignites at the ordinary Diesel temperature and provides a flame to positively ignite the tar when it enters the combustion chamber. This plan demands a fuel valve that has separate tar-oil and gas-oil connections, as well as separate fuel pumps. In the Koerting valve in Fig. 4, the ignition oil is deposited at *A*, just behind the nozzle plate, and the tar at *B*, and as the valve opens the air blast blows the ignition oil in ahead of the tar."

The Electrical Study Course—Types of Three-Wire Generators

Discusses the various types of generators that can be used for three-wire service, and brings out the differences in operation that must be observed and the points that require attention when making field-coil connections.

THE discussion regarding three-wire generators that has preceded the present lesson was confined almost entirely to a consideration of two-pole machines, and nothing was said regarding the method of excitation to be used. A brief summary of the various types of machines that can be used for the purpose will therefore be given.

In the first place it is to be understood that, as in other direct-current generators, the armature is drum-wound and not ring-wound, as indicated in the diagrams used throughout the discussion. As previously explained, the ring type of representation was employed merely in the interest of clearness of presentation. The armature winding, therefore, does not differ from that which would be used in any direct-current generator of the same voltage, the only difference between the armature of an ordinary two-wire generator and that of a three-wire generator being that the latter is provided with slip rings in addition to a commutator, and that these rings are connected to points on the winding that are diametrically opposite one another.

Since the object of the three-wire generator is to supply current at a constant voltage, it must be of the constant-voltage type. It was found at the time that generators were under discussion that there are two types that may be classed as constant potential; namely, the shunt and the compound. It follows that three-wire generators may be of either of these two types. As in the case of two-wire generators, the compound type is the one used most extensively, since the voltage is not only self-governing, but by suitable overcompounding can be made to increase with increase of load in order to compensate for the voltage, or so-called *IR*, drop in the mains, thereby maintaining a constant voltage at the load itself. Moreover, just as in shunt and compound two-wire generators, interpoles may be used in three-wire machines and are so used. The choice of the number of poles is a matter of design as it is in the two-wire generators, and there is no condition met with that does not also figure in the two-wire type.

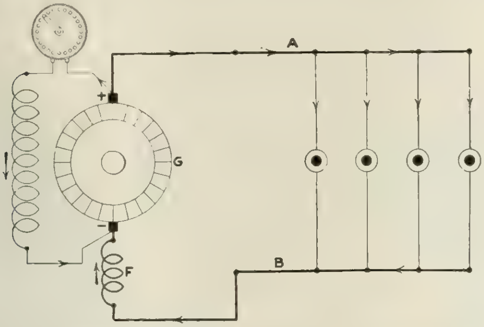


FIG. 1. TWO-WIRE COMPOUND-WOUND GENERATOR CONNECTED TO A LOAD

In the case of a compound three-wire generator there is one complication to which attention must be drawn. Referring to the connections for a two-wire generator of this type, such as illustrated in Fig. 1, it is clear that whatever current flows in one main *A* must also flow in the other one *B*, and therefore all the current delivered by the armature *G* must flow through the series field *F*.

Consider, now, the case of a three-wire generator connected to a three-wire system, as illustrated in Fig. 2. When the system is balanced there will be no current in the neutral *N* and the current in *B* will be the same as that through *A*, and the conditions will be the same as in the two-wire system of Fig. 1. Assume, now, however, that the load is unbalanced; for example, that more lamps are turned on at *X* than at *Y*. There will then be less current in *B* than in *A*, and consequently less current through the series field *F* than is delivered by the armature *G*. The extreme case would be that in which all the lamps at *X* were turned on and all those at *Y* turned off. There would then be no current through *B* and therefore none through *F*. That is, although the generator would be delivering half its rated output, there would be no current through its series field and consequently no series-field magnetic flux to keep the voltage from dropping with increase of load. In other words, the machine would behave as a shunt instead of as a compound generator.

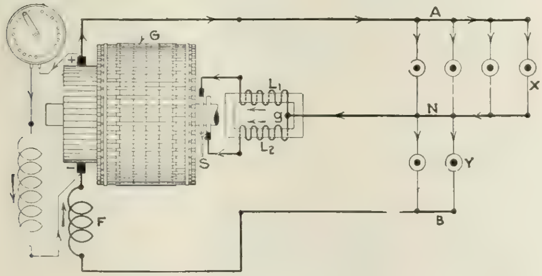


FIG. 2. THREE-WIRE COMPOUND-WOUND GENERATOR; SERIES-FIELD WINDING IN ONE SECTION

On the other hand, if all the lamps at *Y* were to be turned on and those at *X* were all to be turned off, there would be no current in *A*, and *B* would carry full-load current, causing full-load current to flow through *F*. The series-field excitation would therefore be the same as it would be if all the lamps in both *X* and *Y* were turned on, and it would give as much compounding in the one case as in the other.

To overcome these disadvantages it becomes necessary to connect one half of the series-field winding into one side of the circuit and the other half into the other side, as F_1 and F_2 in Fig. 3. This offers no difficulty, since there are always at least two poles, and since each pole has its share of the series-field winding wound upon it. With this arrangement the currents in *A* and *B* each produce the correct amount of magnetization. Thus, if load *X* is maximum and load *Y* zero (in which case the load on the generator is 50 per cent. of normal), full-load current will flow through F_1; or if *X* is zero and *Y* is maximum the same conditions hold except that the current passes through F_2. In either case the series-field effect is due to full-load current passing through half the total series-field winding, and therefore has approximately only half the effect that would be present if full-load current were to flow through the entire series-field winding.

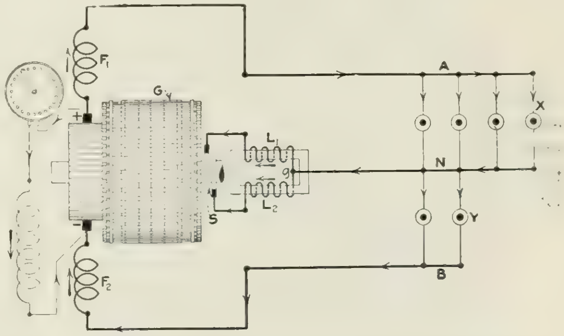


FIG. 3. THREE-WIRE COMPOUND-WOUND GENERATOR; SERIES-FIELD WINDING IN TWO SECTIONS

When both *X* and *Y* are loaded the maximum amount, the generator carries full load and full-load current flows through *A* and *B*, causing full-load current to flow through both F_1 and F_2; that is, causing full-load current to flow through the entire series-field winding and therefore giving the full series-field effect. If the machine is a multipolar one it would be necessary to connect alternate series-field windings in series somewhat as shown in Fig. 4, which represents the connections for the series-field windings of a six-pole compound-wound three-wire generators. (The shunt-field windings are not shown.)

The argument in reference to series windings applies equally to those on interpoles. That is, when a three-wire generator is of the interpole type, half the interpole windings must be connected into one side of the system and half into the other, otherwise there would be times when too little current would flow through them and others when there would be too much. The distribution of the windings can be accomplished in the same manner as with the series windings; namely, by connecting alternate ones in series and then connecting one group to the positive armature terminal and the other to the negative one.

If the machine is a compound one, each group of interpole windings would of course be connected in series with one group of series-field windings. In connecting up the series and interpole windings of such machines, great care must be exercised to make the connections in such manner that the magnetic poles created by the current through them shall have the correct polarity. If the poles created by the shunt-field winding are those indicated by *N* and *S* in Fig. 4, the connections for an interpole machine would have to be those of Fig. 5 if the direction of rotation is that indicated by the arrow *K*. If the direction of rotation were the reverse, as indicated by the arrow *K* in Fig. 6, the connections would have to be changed to correspond to those shown in that figure. It is to be noted that in the latter case the polarity of the brushes would be the reverse of what they were in the former, which fact must be taken into account in making the connections between the fields and the brushes.

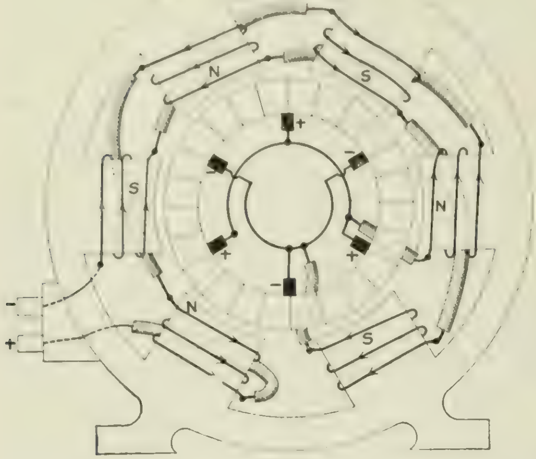


FIG. 4

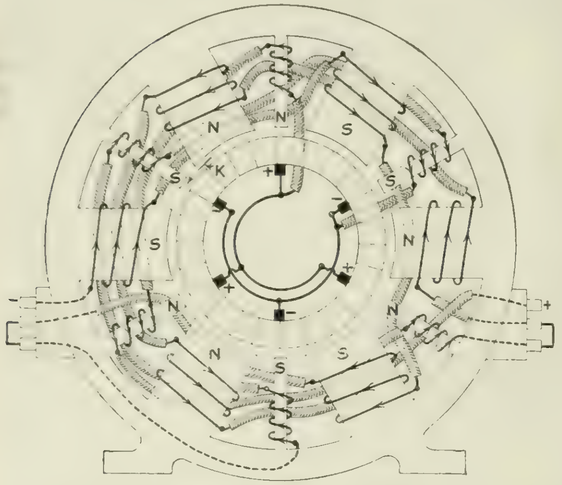


FIG. 5

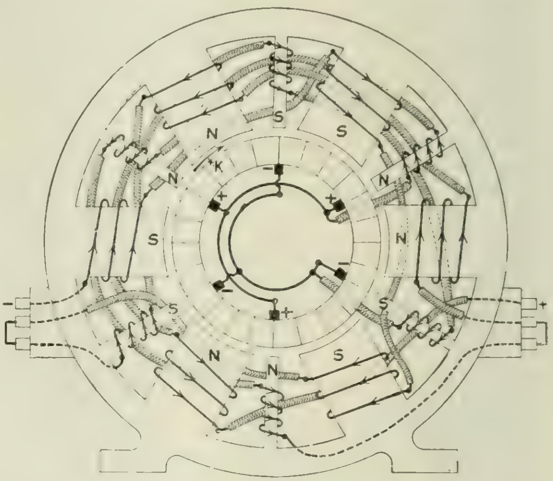


FIG. 6

FIGS. 4 TO 6. SERIES- AND INTERPOLE-FIELD WINDING CONNECTIONS FOR THREE-WIRE GENERATORS

In the problem of the preceding lesson it was required to compute the voltage across each of two resistances connected in series to a source of 110 volts, as indicated in Fig. 7. It was furthermore required to determine the voltages that would be indicated by a voltmeter whose resistance is 14,372 ohms, if it were to be connected across each of the resistances in turn.

The actual voltage across each resistance would be equal to the current through it multiplied by its resistance. Since they are in series, the current through each is the same, and if we represent it by *I*, and the voltages across R_1 and R_2 by E_1 and E_2 respectively, we have, $E_1 = IR_1$ and $E_2 = IR_2$. The current *I* is equal to the sum of R_1 and R_2 divided into the voltage across them; namely, 110 volts. That is, $I = \frac{110}{R_1 + R_2} = \frac{110}{6000 + 2500} = 0.012941$ ampere. Substituting in the expressions for E_1 and E_2, we have, $E_1 = IR_1 = 0.012941 \times 6000 = 77.65$ volts, and $E_2 = IR_2 = 0.012941 \times 2500 = 32.35$ volts. That our computations are correct is shown by the fact that the sum of the voltages is equal to the total voltage; that is, $77.65 + 32.35 = 110$ volts. Placing a voltmeter whose resistance is 14,372 ohms across R_1 is equivalent to changing the conditions to those represented in Fig. 8, in which R_v represents the resistance of the voltmeter. The voltage across *ac* will now be equal to the combined current through R_v and R_1 multiplied by their joint resistance. If we let I_t represent the total current and R_p the parallel resistance, we have, that $E_1 = I_tR_p$.

We first find the value of R_p, which we get from the relation $R_p = \frac{1}{\frac{1}{R_1} + \frac{1}{R_v}} = \frac{1}{\frac{1}{6000} + \frac{1}{14372}} = 4232$ ohms. Then I_t is found by dividing $R_p + R_2$ into the voltage across the two (namely, 110 volts), according to which, $I_t = \frac{110}{R_p + R_2} = \frac{110}{4232 + 2500} = 0.01634$ ampere; from which we have, $E_1 = I_tR_p = 0.01634 \times 4232 = 69.15$ volts. When the voltmeter is connected across R_2 the same course of reasoning would be followed and we would in that case have $E_2 = I_tR_p$, where $R_p = \frac{1}{\frac{1}{R_v} + \frac{1}{R_2}} = \frac{1}{\frac{1}{14372} + \frac{1}{2500}} = 2130$ ohms, and $I_t = \frac{110}{R_p + R_2} = \frac{110}{2130 + 6000} = 0.01353$ ampere, making $E_2 = 0.01353 \times 2130 = 28.82$ volts.

It is thus apparent that the voltmeter readings could not be depended upon to give the actual voltages existing across the resistances at the time the voltmeter is not in use. Thus, the actual voltage across R_1 is 77.65 volts, whereas the voltmeter would read only 69.15 volts; and the actual voltage across R_2 is 32.35 volts, whereas the voltmeter would indicate only 28.82 volts. These discrepancies are due to the fact that the resistance of the voltmeter is not very great as compared with the resistance of R_1 and R_2. When its resistance is very great in comparison (as it usually is), the readings are correct. This will be made clear in the solving of the following problem:

Suppose R_1 to be 7 ohms and R_2 to be 15 ohms. What would be the voltage across each? What would the voltmeter read if connected across each in succession?

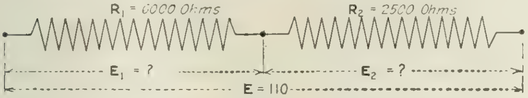


FIG. 7

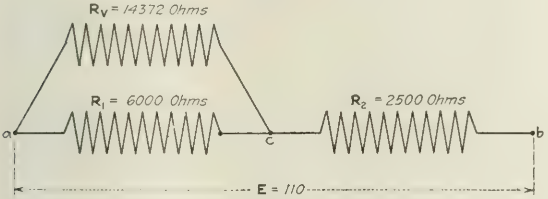


FIG. 8

FIGS. 7 AND 8. RESISTANCES CONNECTED IN SERIES

Specification for Leather Belting

By H. E. Weightman

Coal and equipment for the power plant are commonly bought under specifications, but the men in the smaller plants have not had the necessary data or the talent to write up a good specification for leather belting. In view of this state of affairs, the following is submitted, in the hope that it will give valuable information and serve a useful purpose. It was written in 1909 and changed from time to time as experience indicated. But no changes were made until thorough investigation and fair trial showed them worthy of being incorporated in the specification.

Manufacture—The quality and preparation of the leather and the methods and workmanship used in the manufacture of belts or belting ordered under this specification shall be such as to insure the qualities called for in the completed product.

Inspection—The Blank Company reserves the right to reject any belt or belting which does not conform to the requirements of this specification. In addition to the inspection which will be made on each belt, the right is reserved to reject any belt which develops, after it has been put in service, evidence of inferior material, improper methods of manufacture or poor workmanship, or when it is shown that a belt does not conform with the requirements of this specification.

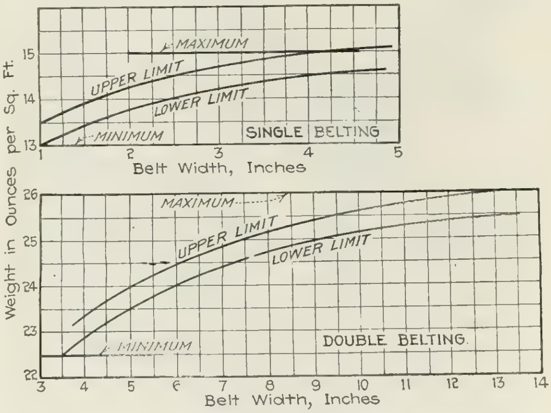
Guarantee—Any belt which is rejected under any of the conditions covered under "Inspection" shall either be repaired or replaced promptly by the manufacturer free of any charge to the Blank Company, or upon its return to the manufacturer full credit shall be allowed the Blank Company, for the cost of the belt. The choice of action in this case rests with the manufacturer.

Material—All leather used in the manufacture of belts furnished under this specification shall be made of No. 1 native packer steer hides from which all shoulder and flank stock has been removed. The leather shall be of what is known as "center stock." The strips shall be cut parallel to the direction of the center of the backbone.

Uniformity—Uniformity in thickness must be obtained by selecting plump, even stock and not shinning or filling for double belting and splitting or shaving for single belting.

Preparation—All leather shall be tanned thoroughly with pure oak bark by the process of tanning in cold liquors. Each individual piece shall be stretched until the elasticity is removed.

Construction—All belting shall be made strictly short lap containing sectional pieces longer than 50 in. cut from the center portion of the hide. The backbone markings in the hide shall be discernible in all finished belts 10 in. in width or wider and in the case of double belts on both sides. In double belting less than 10 in. in width the two pieces which are cut from relatively the same position on the two sides of a hide shall be placed together to form the two sides of the same part of the belting. They shall be placed together in such a way that the head end of the strip on each side of the belt will be against the butt end of its mate on the other side. All connecting shall be done under hydraulic pressure.



LIMITS OF WEIGHT FOR LEATHER BELTING

Weight—The weight of belting shall be within the limits given on the attached curves.

Finish—All belting shall be finished without oil dressing and without rivets, pegs or other fasteners.

The Compound Air Lift

BY A. W. ALLEN

In this article a compound air lift is described, constructed from piping and fittings which will again be available for ordinary use when a pump is installed or the water is allowed to rise.

THE compound air lift is suitable where objections may be raised against the construction of a sump of sufficient depth to satisfy the efficiency requirements of an ordinary single lift. It is also applicable when the available pressure of air is low. The depth of the various stages can be adjusted in this particular, but it must be remembered that a very low available pressure is likely to cause unnecessary complications in the arrangement by introducing too many units. This necessitates a proportionally large number of pipe fittings and increases friction. Under such conditions the system is not recommended, although exceptional cases may call for exceptional methods of treatment.

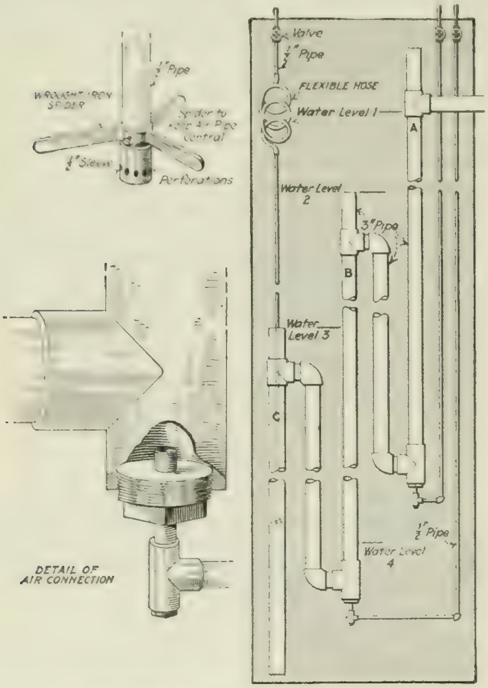


DIAGRAM OF COMPOUND AIR LIFT

FUNDAMENTALS OF A COMPOUND AIR LIFT

A compound air lift is merely two or more simple air lifts arranged in series—the rising main of the first discharging into the sump of the second and so on. A loss of fall at each stage is inevitable, and this also involves a small loss of power. The system can be arranged to duplicate or triplicate any of the ordinary designs in use; and the customary self-regulating features can be incorporated in each of the various units.

I once had occasion to utilize the compound air-lift principle under somewhat unusual circumstances. An old mine working had to be dewatered to drain an adjoining shaft. The old working had to be drained as far as possible by a system that made personal attention near the water level unnecessary.

A small compressor furnished air at a low pressure, and even if a pump could have been made to do the work, there would continually have been the danger of interment of both the pump and anyone who happened to be attending to it. A compound air lift was therefore constructed, which permitted the gradual lowering of the water to a level in proportion to the depth of successive submergences, and so personal risk was eliminated. Soundings disclosed the fact that timbers had collapsed to such an extent that only a narrow channel remained in one place. This was found sufficient, however, to permit the passage of the lift pipes.

A somewhat diagrammatic drawing of a compound lift of this class is shown in the illustration, but in actual construction it is, of course, possible to bunch the various pipes and so insure greater compactness than is indicated. Strainers, attached to the foot of the lowest lift and at other necessary points, are advisable and should be made of ample dimensions to obviate any throttling of the intake.

The need for the constant shifting and readjustment of the pump, as the water lowers, can be avoided by constructing the apparatus complete and by placing it at the lowest point in the first instance; and then by pumping the water in stages. The various pipes can be assembled and the added sections bolted or screwed together as the pump is lowered. Permanent air connections are indicated, but can be omitted when it is considered preferable, and flexible connections used instead. The permanent connections were available, in the instance under description, only when the pressure had been reduced by the help of the flexibly connected air pipe.

PERMANENT AIR CONNECTIONS

It will be noticed that the permanent air connections are attached through a plug at the lower arm of a T-piece in each case. This design was purposely adopted to minimize friction, as it was found that the extension of the air pipe into the rising main served no useful purpose and, furthermore, constricted the suction of the pump. By arranging the supply as shown, it was found that there was no tendency for the air to escape other than where it was needed, except when an unnecessary volume was being used.

There is one disadvantage in the use of the flexible air connections and a loose pipe system, apart from the fact that the introduction of another pipe in the rising main increases the frictional resistance, and that is due to the fact that the air pipe may rest against the side of the lift pipe. This will result in a partial distribution of the air through the liquid. The objection may be of little account in the case of small lifts, but should be avoided in large ones. The ill effects may be reduced by bolting a "spider," of three arms, to the outside of the air pipe, near the bottom, which will maintain it in a central position (see illustration). The arms must be of such a length that the "spider" forms a very loose fit in the inside of the rising main. It is preferably made of wrought iron and is kept from slipping off at the bottom of the pipe by means of a sleeve which may be bored around its lower end, in the manner shown, in order to distribute the air more effectively.

Operation of Compound Lift With Flexible Air Connections

By reference to the diagram it will be seen that four water levels are given. It may be assumed that level No. 1 shows the original position of the water. The flexible air connection is then put into the rising main *A* to a depth consistent with available pressure, and gradually lowered therein as the water is reduced in the shaft until level No. 2 is reached. The flexibly connected pipe is then withdrawn from the rising main *A* and transferred to *B*. As soon as the second lift is in operation, water will be delivered so that lift *A* can be operated by means of the permanently connected air pipe. As soon as water level No. 3 has been reached, the flexible connection is withdrawn from air lift *B* and transferred to *C*. As soon as this is in operation, the permanent connection to supply air for lift *B* can be used. The final water level will be approximately as shown at No. 4, with the air pipe at the bottom of the lowest lift pipe.

Ratio of submergence to lift will vary in such installations according to local conditions. Economy in small lifts may demand a ratio of from 1½ or 2 to 1 of submergence as compared with the lift. In other instances economical work is of secondary consideration, especially where the air pressure is low, and a shallow submergence may be adopted.

The arrangement shown permits the easy escape of the air when lifting is accomplished. Spasmodic or jerky delivery of water usually indicates faulty conditions as to air volume or submergence ratio, which should be regulated as far as practicable to insure a more or less even stream from the discharge pipe.—*Engineering and Mining Journal.*

Boiler Patches and Diagonal Joints

By C. B. Linstrom

Good judgment must be exercised to determine the best and most economical means of making boiler repairs so as to insure that the affected parts will withstand the working conditions to which the boiler is subjected. One of the most frequent repairs met with is the application of boiler patches. Patches may be applied on either the outside or the inside of cylindrical shells or tubular, Scotch marine and locomotive boilers, or on drums of water-tube boilers. It is not the practice to place patches on the outside of shell plates directly exposed to the fire.

Another repair often met with is that of bagged or bulged shell courses. Such deformations occur at the bottom of the shell in tubular boilers and are due to the overheating of the plate. Accumulation of sediment and scale forms a mass that prevents the water from coming in direct contact with the metal, and the result is overheating. A small bag can be repaired by reheating the part affected and driving it back, but in some cases the damaged section of the plate is removed and a patch is applied. A bulge extending over a large area cannot be handled in this way. The only recourse in such a case is to apply a new plate section to the shell course.

Boiler patches are made in various shapes, and they should be so designed as to give the strongest seam possible. A patch of the form shown in Fig. 1 is undesirable, as the seams *AB* are horizontal, giving a very small joint efficiency when single-riveted. The one in Fig. 2 is a half-moon patch and is commonly applied between shell courses along the girth seam. Fig. 3 is an elliptical patch and Fig. 4 a diamond-shaped patch. The seams in Figs. 2 to 4 are diagonal and are stronger than seams of like proportions when arranged as at *AB*, Fig. 1.

For a given pressure the stress per inch of joint in a boiler is twice as great in the longitudinal seam as in the girth seam; consequently, the efficiency of the girth seam need be only half as great as the efficiency of the longitudinal seam. This explains why girth seams are usually single-riveted. The ratio of the stress on the seams being 2 to 1, it is evident that a diagonal seam of the same proportions as a horizontal seam will have an effective efficiency lying between the efficiency of the longitudinal seam and its efficiency if it were a girth seam. Therefore, the effective efficiency will vary according to the angle the diagonal joint makes with the girth seam, and the nearer it approaches the position of the girth seam the stronger it becomes.

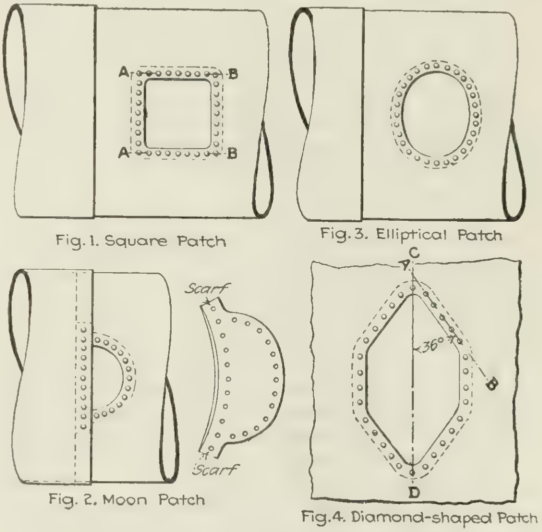


Fig. 1. Square Patch

Fig. 3. Elliptical Patch

Fig. 2. Moon Patch

Fig. 4. Diamond-shaped Patch

FIGS. 1 TO 4. FORMS OF PATCHES USED ON BOILER SHELLS

To calculate the efficiency of a diagonal joint, first determine the joint efficiency as for a longitudinal seam; then multiply the result so found by the factor corresponding to the angle the seam makes with the girth seam, which is found by the formula

$$Factor = \frac{2}{\sqrt{3 \times \sin^2 A + 1}}$$

in which *A* represents the angle that the diagonal seam makes with the girth seam. To obviate the use of the formula for each individual problem, the table has been worked out, giving the values of the factor corresponding to various values of the angle *A*.

To illustrate the calculation of a diagonal-joint efficiency, consider the arrangement of the seam and patch in Fig. 4. The joint is a single riveted lap seam, diameter of driven rivets $\frac{13}{16}$ in., plate thickness $\frac{3}{8}$ in., pitch of rivets 2 in. Assume 38,000 lb. per sq.in. as the shearing resistance of the rivets and 55,000 lb. per sq.in. as the tensile strength of the plate.

First determine the joint efficiency as for an ordinary longitudinal seam, using as a basis a length of joint equal to the pitch, or 2 in. The tensile strength of solid metal in a strip of this length is 55,000 × 2 × $\frac{3}{8}$ = 41,250 lb. The strength of the metal between rivets in one pitch is (2 — $\frac{13}{16}$) × $\frac{3}{8}$ × 55,000 = 24,492 lb. Then the efficiency of the net plate section as compared with the solid plate is 24,492 ÷ 41,250 = 59.4 per cent.

FACTORS FOR FINDING EFFECTIVE EFFICIENCIES OF DIAGONAL JOINTS

Angle A Deg.	Value of Factor	Angle A Deg.	Value of Factor	Angle A Deg.	Value of Factor
30	1.51	42	1.31	54	1.16
32	1.47	44	1.28	56	1.14
34	1.44	46	1.25	58	1.13
36	1.40	48	1.23	60	1.11
38	1.37	50	1.20	62	1.09
40	1.34	52	1.18	64	1.08

The rivet efficiency, which must also be considered, is determined by finding first the strength of the rivets to resist the shearing and crushing stresses and then dividing the value so found by the strength of the solid plate section. The smallest efficiency found for the joint is the one to be used in determining the pressure to be allowed on the seam.

The strength of the rivets to resist shearing is found as follows: Area of driven rivet = $(\frac{13}{16})^2$ × 0.7854 = 0.5185 sq.in. Then, 38,000 × 0.5185 × 1 = 19,703 lb., shearing resistance, and the rivet efficiency is 19,703 ÷ 41,250 = 47.8 per cent.

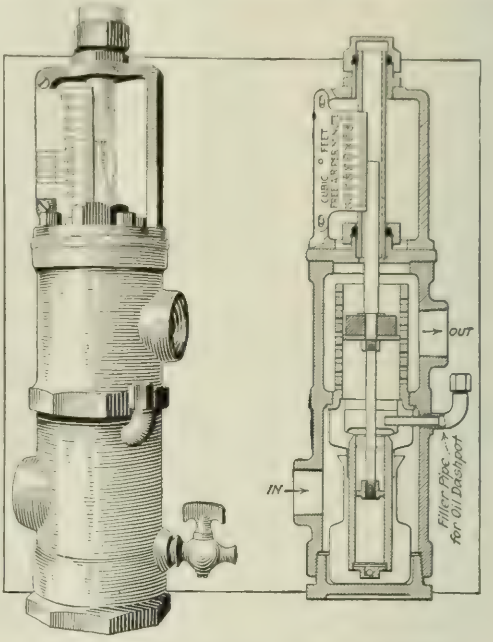
The joint may fail by crushing of the plate in front of the rivets, so the strength of the plate section to resist crushing should also be found and the efficiency of the joint in this respect determined. Assume 95,000 lb. per sq.in. as the crushing strength of boiler steel. Then, the crushing strength of the metal in the cross-sectional area in front of one rivet is $\frac{13}{16}$ × $\frac{3}{8}$ × 95,000 = 28,945 lb., and 28,945 ÷ 41,250 = 70 per cent. efficiency of joint to resist crushing of metal in front of one rivet. The smallest efficiency is that of the rivets, which is 47.8 per cent.; therefore the diagonal-joint efficiency is determined from this value. The factor for the diagonal seam *AB*, Fig. 4, which in this case makes an angle of 36 deg. with the girth seam *CD*, is found from the table to be 1.40. Then, 47.8 × 1.40 = 66.9 per cent., the efficiency of the diagonal joint.

New Jersey Air Tool-om-eter

The volume of a definite compressed fluid or gas flowing under small constant head through multiple orifices of the same shape and size is directly proportional to the number of orifices exposed to the flow. This is the principle upon which the New Jersey air tool-om-eter is designed. This meter, manufactured by the New Jersey Meter Co., Plainfield, N. J., shows direct on a scale, in cubic feet of free air a minute, the flow of air in a pipe. It is capable of measuring the air consumption of any machine or application of compressed air and the actual net production of air by any compressor or pump within its capacity.

In operation, a small head or difference of pressure is established between the interior of the cylinder and the outlet chamber, this pressure difference (but a few ounces per square inch) being fixed by the exact weight of the moving element and the area of the pistons on which the difference of pressure acts. The moving element rises until the weight is exactly supported by the difference in pressure; the pistons and rod are then floating in static balance in a position corresponding to the volume of the air flowing, the number of holes exposed and the height of the top of the rod in the sight glass. The meter automatically adjusts itself to the conditions required by the principle, or natural law, as already stated. The divisions of the scale plate are calipered by comparison with a standardized instrument to read correctly.

This instrument is not a velocity meter, which would give readings proportional to the square of the volume flowing, but is a direct volume gage with a uniform scale on which one cubic foot is represented by the same distance whether working at low or at high capacity. A sectional view of the instrument is shown.



EXTERIOR AND SECTION OF TOOL-OM-ETER

This meter will detect and measure leakages in air lines, valves, hose, etc., determine the net volume of air produced by compressors for comparison with nominal rating or displacement and show where the air goes after it is compressed.

The meter has but one moving element, which floats on the air and is practically frictionless and nonwearing.

Alcohol can be made from starches, sugars, wood waste, sulphite liquors from paper manufacture, peat, cornstalks and various other materials. It has been estimated—on a pre-war basis—that alcohol will compete with gasoline as a commercial fuel when the cost of gasoline goes above 35c. a gallon.

Some firemen regulate the draft by kicking the ashpit doors open or shut at intervals. The proper way is to regulate the draft by the damper, which, by the way, is easier on shoe leather.

EDITORIALS

Why Wait?

BUSINESS today is imbued with an air of hesitancy, a condition that is admittedly psychological in view of the markets to be met and the stocks to be replenished after the drain occasioned by the war. Nor can it be said that industry is not aware of the opportunities ahead, but it appears to have adopted a sort of "watchful waiting" policy for prices to go down.

What, then, are the prospects of prices dropping?

Economists are agreed that there will not be any general fall in prices, and certainly not in the near future. Their conclusions are supported by the fact that the price of labor which enters so largely into every commodity has attained a new standard from which it is most certain not to recede. Moreover, history teaches that prices after all great wars have never returned to pre-war standards.

Here and there, where abnormal inflation exists, there will undoubtedly be some readjustment, but we must all face the fact that a new price level has been reached and that the value of the dollar has diminished.

The condition is not by any means local to this country; it is world-wide, and more pronounced the closer to the fighting area. In England, for instance, steel is much higher than in the United States, and the same is true of other commodities. Therefore, there is little to fear from foreign competition.

That most men fail to look beyond the relatively small sphere of their own business is only too true. Moreover, they lose sight of the fact that the greatest profits are usually made during periods of high prices.

But granting, in spite of all evidence to the contrary, that there might be a slight falling off in the next six months, the man who waits will be the loser. He is not only sacrificing the income and turnover on his investment during the interim, but is passing up opportunities to get in on the ground floor with the new business that is courting attention.

Therefore, why wait?

A General Engineering Society

THE nebulous idea, which has been acquiring density and consistency for some time past, of uniting the various branches of the engineering proprofession in an all-inclusive organization, is taking definite form. In the committees appointed by several of the societies to consider plans of reorganization which shall render the engineering societies of greater service to the community and the profession, the conception is growing of a federation composed of local and national engineering societies.

Local societies, unlike the professional national societies are generally all-inclusive. They invite to membership not only different kinds of professional engineers such as civil, mechanical, mining, electrical, chemical, metallurgical, etc., but also engineers of the nonprofessional class such as draftsmen, rodmen, operating engineers, sales engineers, etc. Thus they unite a large engineering group for the purpose of acquaintanceship and solidarity, for the hearing and discussion of engineering papers and lectures, and therefore they can bring to bear on local problems involving engineering features the organized engineering force of the community.

Such associations can act and in some cases are acting unitedly in matters of state or district interest by the appointment of joint committees upon occasion or the maintenance of permanent state or district associations.

The national general engineering society would take care of matters of general and national scope and would be composed of representatives from the local groups and from the professional and other national engineering societies. Local sections of the national professional societies may remain constituent parts of the local general engineering societies, as is now frequently the case, functioning as sections of their parent bodies in matters relating to these societies, but acting also, in matters of general local concern as individual units of the local general engineering society.

There would thus be built up a great democratic America-wide association uniting the engineering thought, talent and sentiment of the continent, organized for local and national activities, of which the existing specialized professional societies, national or otherwise, could become a part without losing their identity. The more the plan is studied the better it seems to meet the aims of those who aspire for a more universal organization of the engineers of America without arousing the apprehensions of the existing societies.

Industrial-Lighting Codes Safety-First Measures

THE safety-first movement has been gradually manifesting itself in many forms during recent years, such as safety-first organizations in individual manufacturing plants, the "National Electric Safety Code" of the Bureau of Standards, state compensation acts and various codes for guarding the welfare of industrial workers. Among the latest additions to the number of state regulations for preventing injury to the health and limbs of employees in the industries are the lighting codes adopted by a number of states. As pointed out by G. H. Stickney in his paper, "Present Status of Industrial-Lighting Codes," presented before a joint meeting of the American Institute of Electrical Engineers and the Illuminating Engineering Society, held in New York City recently, "The industrial lighting codes are an expression of the safety-first movement in terms of legal regulations directed to the lighting of factories. The prime function of the codes is the safeguarding of life, limb and vision of industrial workers."

The fact that statistics show that twenty-three and eight-tenths per cent. of all industrial accidents are caused by insufficient or improper lighting should be all the argument necessary to establish the industrial lighting codes as an expression of the safety-first movement, and to enlist the support of all managers and others in a position to see that proper illumination is installed in manufacturing establishments and power plants. Translating the above percentage into terms of economic waste it is equivalent to the loss of approximately one hundred and forty thousand employees per year of three hundred days. If only fifty per cent. of this loss in productive labor can be saved, a real economic advance will be made, to say nothing of the humanitarian considerations, which are of vastly more importance. In the introduction to the new edition of the Wisconsin Code, the necessity of such regulations are shown in the following statement: "Insufficient and improperly applied illumination is a prolific cause of industrial accidents. In the last few years numerous investigators, studying the causes of accidents, have found that the accident rate in plants with poor lighting is higher than in similar plants which are well illuminated. Factories that have installed approved lighting have experienced gratifying reductions in their accidents. To conserve the eyesight of the working class is a distinct economic gain to the state, but regardless of that, humanitarian considerations demand it." In addition to the foregoing advantage, production, it has been estimated, can be increased fifteen per cent. by the introduction of the proper illumination in our industries. Also the spoilage due to defective workmanship can be greatly reduced.

Poorly lighted passageways are prolific sources of accidents, and strange as it may seem, power plants are among the chief offenders in this respect. This comes about in general through insufficient illumination or none at all, or by allowing lamps and shades to become so dirty as to make them practically useless. On the other hand, lights so installed as to give intense glare are as bad as or worse than no light at all, and are also the cause of many accidents in places that are supposed to be illuminated. The prevention of injuries to body and health by better illumination marks another step in our industrial progress, and it will be well for all industrial-plant managers and power-plant engineers to have their plant illumination installed and maintained to conform to the best modern practice.

A Double-Barreled Investment

SOME misguided and ignorant folk have declared that they have no interest in the success of the Victory Loan campaign now under way. They insist that the war is over and that the need of war funds ended with the cessation of hostilities.

We wish that their statements were true and that as a consequence we might indorse their attitude. But the truth is that every citizen—yes, and every noncitizen—has a very vital interest in the floating of this final loan.

There are two arguments that should be brought to bear on the person who is able to subscribe to the present loan, but who is holding off because he feels no particular concern in it. Either one is sufficient to show how advantageous it will be for him to subscribe to the limit of his ability.

First of all, every one of us is eager for the return of prosperous times in business, but the prosperity of business is intimately bound up with the condition of the money market. If money is scarce and interest rates are high, credit is restricted and expansion of business is hampered. The result is stagnation and industrial depression. Therefore, the man who invests in Victory Notes, by mortgaging his future earnings, aids the banks in lending at reasonable rates and so hastens the return of those piping times of peace fo which we are all yearning.

The second argument is an appeal of a purely selfi nature. The rate of interest on the new loan is highe than on any of the preceding ones and is therefore particularly attractive to small investors. It far exceeds the return to be obtained from savings banks, and the investment is so gilt-edged as to make ordinary stocks and bonds look like tarnished brass by comparison.

Subscriptions to the Victory Liberty Loan not only insure a high return in the matter of interest, but hasten the reëstablishment of business on a normal footing.

Killing two birds with one stone has always been considered an economical and thrifty performance. It is doubly commendable when applied to the purchase of Victory Notes.

In a memorable speech last week before the Seventh Annual Convention of the United States Chamber of Commerce, at St. Louis, Secretary Glass of the Treasury Department said: "The American people should supplement the patriotism of war by the patriotism of peace, and just as the American soldiers on the field battled to notable conquest for liberty, so American business men in different ways and through different instrumentalities should now give expression to their patriotism by promptly and cheerfully meeting the obligations of citizenship, the foremost obligation of which is to guard jealously the honor of the Nation; to regard its commitments as his own, and willingly contribute his labor and his substance for complete payment of our debt in the spirit of the National Prosperity Campaign, whose efforts for the stimulation of business and confidence have been spread broadcast throughout the country over the slogan of LET'S GO." This is ample evidence that the Government is heartily in support of the idea.

C. A. Graves in another column calls attention to the lack of measuring instruments in boiler rooms. Mr. Graves was engineer to the New York State Fuel Administrator and speaks from observation of a large number of cases. If engineers would impress their employers with the gains to be expected from the use of such apparatus and with their ability to handle it to advantage, there would be more of it in use.

Water-gage glasses frequently burst in the boiler room, and care should be taken to see that they are properly guarded. By the way, how many water-glass guards have you in your plant?

The fireman who will shovel sufficient coal into a furnace so as to permit him to sit down for half or three-quarters of an hour will never make a record with a CO_2 recorder.

Well-polished brightwork in an engine room is like the cherry in a cocktail—it doesn't have any noticeable influence on the action, but it certainly does add to the attractiveness.

Nitrogen in the air supplied to a boiler furnace must feel just about as useless as snowshoes on a Hottentot.

Correspondence

Noisy Compressor Valves

Recently, I had an experience with slamming air-compressor valves. The compressor delivers air at 15 lb. pressure, and "according to the oldest inhabitant" the valves had always been noisy. The seat was made at an angle of 45 deg. and is 3½ in. diameter. The outside diameter of the valve was 4 in., with 1-in. lift, and it was held to the seat by a spring made of steel 0.145 in. in diameter and 11 in. long, with 20 coils. It requires 18 lb. to compress it 6¼ in., the closed position of the valve.

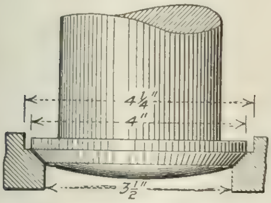


FIG. 1. LOW VALVE SEAT FROM REGRINDING

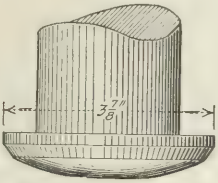


FIG. 2. NEW DIAMETER OF THE VALVE

Originally, the seats came flush with the surface of the valve deck, but repeated grinding and reseating had brought them about ⅜ in. below the surface, as shown in Fig. 1. Someone had bored the deck surrounding the seat to a diameter of 4¼ in. to provide space for the escape of the air, but it was not enough.

The inside diameter of the contact circle between the valve and the seat was 3½ in. and the outside diameter was 4 in., a difference in area of almost 3 square inches. With 15 lb. pressure per square inch in the cylinder and the same pressure on the discharge side of the valve, there would be an unbalanced pressure of a little more than 44 lb. plus the pressure of the spring, 18 lb., and a little due to the oil film on the seat.

To balance this, the pressure in the cylinder had to rise to about 21.5 lb. per sq.in. As soon as the valve lifted from the seat, on account of the restricted passage for the escape of the air this pressure would be exerted on the 4-in. diameter of the valve with the result that the valve would be thrown back against the stop, causing a slam, and when seating the heavy spring would cause a second slam.

To overcome the first slam I had a part of the valve face turned at an angle of 55 deg., leaving an annular contact circle about ⅛ in. wide, and the outside diameter of the valve turned down from 4 to 3⅞ in., giving more opening for the escape of the air (see Fig. 2). In order to relieve the second slam I changed the springs to weaker ones, making them 9 in. long with 18 coils, 0.125 in. steel, 2⅛ in. outside diameter, and requiring 6 lb. to compress to 6¼ inches.

After these changes were made, the piston began to strike the head, indicating that the clearance had been very slight and that less work was required to deliver the air.

R. McLaren.

Toronto, Ont., Canada.

Factor of Safety of Repaired Flywheel

An old-fashioned box-bed gib-and-key type of plain slide-valve engine built about forty years ago is used for driving the muck rolls in a rolling mill, the 14-in. engine shaft being directly connected to the roll shaft. The cylinder dimensions of the engine are 24 x 48 in. and the speed is about 60 r.p.m. A throttling governor controls the speed.

The flywheel is 20 ft. in diameter and has a 9 x 12 -in. rim section. The rim is made in eight segments, each segment being cast integrally with a single spoke. The eight spokes are secured to the hub by clamping them between cheek-plates as indicated in Fig. 1. Each rim-joint is fastened with a bolt and with two wrought-iron links shrunk into recesses in the sides of the rim.

The engine and flywheel have been several times dismantled and reërected in a different location. In the course of one of those removals a clamping lug on one of the rim segments of the wheel was broken off as shown in Fig. 2. Fig. 3 shows how it was repaired.

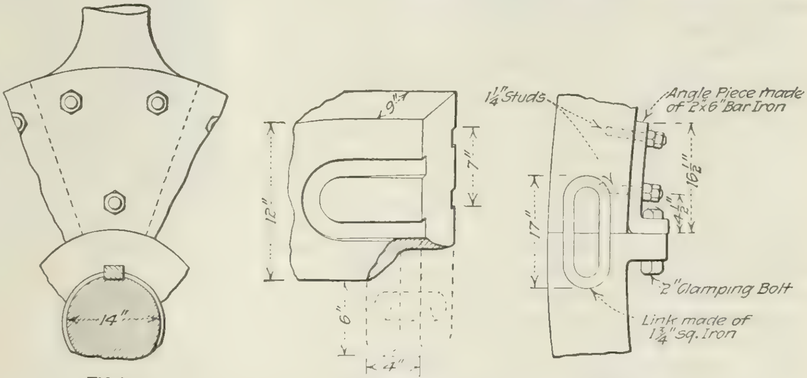


FIG. 1 FIG. 2 FIG. 3

FIGS. 1 TO 3. SHOWING METHOD OF REPAIRING BROKEN LUG ON FLYWHEEL

Fig. 1—Fastening of arm at hub. Fig. 2—Break in lug at rim. Fig. 3—Manner of repairing break

With a centrifugal pull of approximately 26,800 lb. on the rim joint, as is the case with the engine running at 60 r.p.m., the wheel is no doubt amply strong. However, since a patch fastened to anything broken must necessarily lack more or less the efficiency of the original unimpaired construction, it would be interesting to know just how much the factor of safety in this case has been diminished.

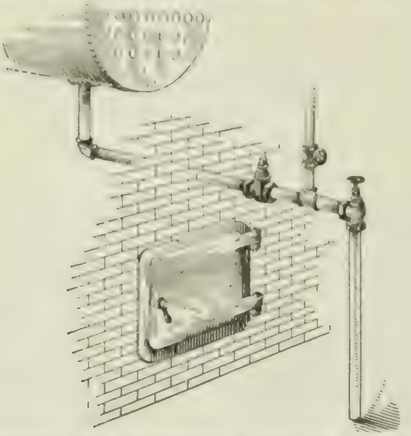
A. J. Dixon.

St. Louis, Mo.

Flushing Boiler Blowoff Valve

I have followed with interest the boiler blowoff discussion in *Power*. On page 818 of the Dec. 13, 1918, issue W. H. Wakeman says exactly what I want to say as regards both the location and the order of operation of the cock and valve, but I would like to add a feature that has given me splendid service.

As shown in the illustration, I inserted a tee between the cock and valve and to it connected a 1-in. line from the feed-water main. This serves me in three ways as follows: In the closing operation I close the cock first, then open the 1-in. line for a few seconds and wash the valve faces clean of all sediment before closing it. This keeps the valve faces tight almost indefinitely. When the valve does need either regrinding or a new disk, the operation can be performed in comfort by letting a little cold water in through the 1-in. line to condense and cool any leakage passing the cock.



PIPING FOR FLUSHING BLOWOFF VALVES

If sediment and scale are allowed to settle in the vertical blowoff line until it will not move out with the boiler pressure, the cock can be opened and the pump pressure raised through the top line and the sediment forced upward into the boiler and blown out.

Vancouver, B. C., Canada. R. Manly Orr.

Feed-Water Check-Valve Failure

A short time ago I was called out to a small power station to look over a tubular boiler that had been reported damaged by low water, and on arriving at the plant found that the boiler had been drained and cooled off to allow an examination by the boiler inspector. After a careful examination of the shell and tubes, he reported that the back head bulged about $\frac{3}{4}$ in. and had pulled away from several tubes; also that the two top rows of tubes and the tube sheet had been burned badly. His immediate opinion of the cause was low water caused by a careless fireman. After hearing his report and listening to the description of the accident by the chief engineer, the writer asked the engineer to get a wrench and take the cap off the boiler-feed check. When this valve was opened, a piece of duck packing from the water cylinder of the feed pump was found wedged under the check so that it could not close.

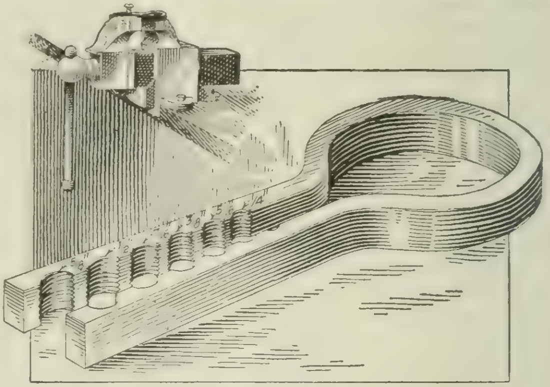
Here is what happened: The engineer had been out of the fireroom about twenty minutes and had just returned when the fireman said he could not hold water in the boiler, although the feed line was wide open. There were three other boilers on the same header taking water from the same pump. The water dropped out of the glass so quickly that it was necessary to pull the fire. The boiler started to leak badly on the top row of tubes. The automatic stop valve closed and cut the boiler off the line. The faster the fireman ran his pump the faster his water fell in the gage-glass. The water rose in the other boilers, due to siphoning action from the damaged one.

If the fireman had closed the feed valves on the other three boilers, or the one on the defective boiler, when the water was going out of the glass, and then pulled the fire, the boiler would have been saved from damage. Sometimes these accidents happen so quickly that the average fireman does not have time to think over all the combinations that can happen. In my 28 years of power-station experience this is the second time I have seen an accident of this kind from the same cause and with the same result. R. J. Fox.

Chicago, Ill.

Simple Machine-Screw Holder

The illustration shows a simple tool to hold machine screws by placing them in the threaded holes and then securing the tool in a vise so as to hold it firmly and still not damage the threads of the screws. The tool is made as follows: First a piece of cold-rolled key stock is bent in the manner shown, after which the ends are placed in a vise with a piece of fuse strip to give clamping room between them. Holes are then drilled and tapped in graduated standard sizes, or any other sizes required, and the tool is case-hardened to prevent damage from filing and sawing. Vaughan Ladd.



SCREW CLAMP AND ITS APPLICATION

Lima, Ohio.

Removing Burnt Oil

Burnt oil can be easily removed from the polished work around the cylinders of engines, etc., by using Bon Ami and rubbing the oily spots with a wet cloth, applying it to such parts while they are hot. It is remarkable how it removes the oil without scratching the polished surfaces. James C. Browning.

Joliet, Ill.

Lack of Power Plant Meters

It is remarkable what a large number of power plants have no means of measuring the water or coal used and therefore can make no comparison of their operation from day to day with standard practice. Even comparatively modern plants of several hundred horsepower have only the usual equipment of steam and water gages.

Although I am not interested in the sale of boilers or of accessories, it seems to me that this condition is largely due to the policy of the boiler manufacturer to sell only boilers. The electric generator manufacturer in many instances, when a generator sale is made, sells all the meters, etc., that can be used. Many accessories are also sold with automobiles.

Purchasers of boilers, however, unless they have competent engineering advice, will not usually consider the installation, with the boiler, of steam or water meters, or soot blowers, or draft gages, because these are classed as extras and entail an additional cost.

If the boiler salesman, in quoting on an installation, would include the desirable meters and accessories, the purchaser would obtain an equipment that would be of the greatest benefit to him.

This seems to be the appropriate time for the boiler men and the accessory men to get together to the advantage of both, with probably the greater advantage to the boiler manufacturer, as complaints on the operation of particular installations can be readily satisfied without the expense of elaborate tests if proper accessories are installed. It is unnecessary to mention the benefit the purchaser would derive from such getting together. C. A. GRAVES.

New York City.

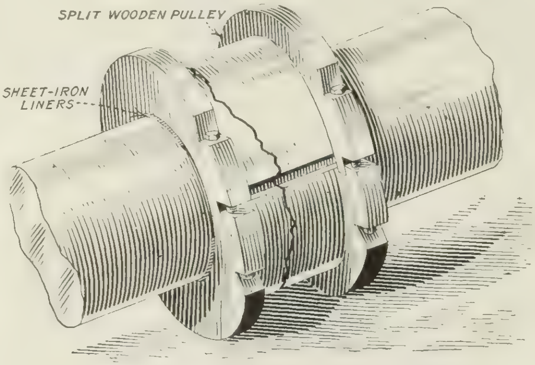
Flywheel Explosion in St. Louis

In the report, published in the Feb. 4 issue of *Power*, page 186, of a flywheel explosion in a rolling mill, it was stated that the accident could be traced to no definite cause. This was true at the time, inasmuch as those in a position to explain the exact cause disclaimed all knowledge of it. Precise information on this point has, however, since come to light.

Measurements taken of a segment of the rim that landed in the third story of a neighboring manufacturing plant showed the wheel to have been 9 ft. diameter, with an 8 x 6½-in. rim section. The wheel was in halves, which were held together at the rim with 1⅛-in. clamping bolts, reinforced by 1-in. oval links shrunk in recesses in the sides of the rim. According to the statement of a man long familiar with conditions in the mill, one of the spokes was cracked through at the hub, the result, no doubt, of rough handling in one of the several dismantling and reassemblings that marked the early history of the engine.

The engine was belted to a lineshaft from which the blast fans were driven. Its cylinder dimensions were 14 x 28 in. and the speed 120 r.p.m. As originally built it was of the automatic cutoff type, with flat valves. Some years ago, however, the automatic features were removed, and with the addition of a throttling governor the engine was converted to the old-fashioned plain slide-valve type. From the statements of men acquainted with the history of these details, it appears that when the change was made, the question of providing a main-shaft pulley for driving the governor belt was answered by pressing into service a discarded wooden split pulley that happened to be of about the right diameter and width. The bore of this pulley was found to be somewhat large for the shaft, but that defect was remedied by lining out the bore with sheet iron. The pulley was made with flanges for holding on the belt and was clamped to the shaft with four $\frac{5}{16}$-in. bolts, as shown in the sketch herewith.

In the course of time cracks appeared in the face of the pulley, and these eventually extended through both halves, as indicated in the sketch. The two ends of the pulley thus developed a tendency to part company in the middle and work along the shaft in opposite directions. To prevent this the ends were bound together with wires wrapped around the clamping bolts. But as it was difficult to draw the wires perfectly taut, this mode of fastening continued to give trouble until someone hit upon the happy idea of wrapping a piece of tin around the pulley and securing it with tacks. One day the oily rubbish that had accumulated in the flywheel pit caught fire from sparks thrown from the rolls, and the flames lapping up around the governor pulley left it badly charred and disfigured and certainly did not improve its holding quality.



HOW THE GOVERNOR BELT SPLIT

As may readily be surmised, this pulley early manifested a tendency to slip on the shaft and so permit the engine to speed up. Whenever this would occur, the bolts would be tightened and perhaps the old liners would be taken out of the bore and new ones with a rougher and more biting surface would be put in their place. One man who had handled the engine for a number of years stated that he found by experiment just how much to open the throttle to keep the governor balls hovering at the point of rising to a running plane with the maximum pressure carried in the boilers. Having the throttle so adjusted, he would secure it by wiring a heavy weight to the handwheel. Another man who had handled the engine for a considerable period, but who had not adopted the precaution just mentioned, states that on several occasions he barely managed to reach the throttle in time to avert disaster.

The bursting of the flywheel was unquestionably due to overspeed caused by the governor becoming inoperative on account of its driving pulley slipping on the main shaft.

Two segments of the exploded rim did considerable damage to manufacturing plants located on opposite sides of the mill—one north and the other south. One of the segments, weighing 407 lb., cut though a 9 x 9-in. wooden truss-beam in its flight through the mill and broke through the roof of a three-story boiler house 600 ft. distant. The angle of elevation of this fragment as it shot out from the disrupted wheel and the parabola which it described in its descent were determined and a trajectory made. Figured on the data given, the rim speed at the instant of disruption was 178 ft. per sec., corresponding to 368 revolutions per minute.

Taking into account the retarding effect of obstacles encountered in its flight through the mill, it is probable that this fragment was projected with a higher initial velocity than the figures show. This view is substantiated by the obvious intensity of the force with which a 1082-lb. segment hit the third-story brick wall of the manufacturing plant standing to the north. A mass of heavy steel structural work was piled against the inner face of the wall. The flying fragment ploughed through this barrier and brought up against the massive steel frame of a riveting machine about thirty feet distant, the final impact further shattering the fragment into three pieces.

Fortunately, the accident happened on a Saturday afternoon, shortly after the employees in the last-mentioned plant had quit work. Had it occurred an hour earlier, it probably would have resulted in death or injury to several. A. J. DIXON.

St. Louis, Mo.

Eliminating Cylinder Oil from Exhaust Steam

From reading the article entitled "Eliminating Cylinder Oil from Exhaust Steam," by W. H. Wakeman, in *Power* of Mar. 11, page 365, it is evident that the matter was handled by rule of thumb without any definite idea as to what was happening in the separator or as to what caused the trouble. This question can be analyzed as follows:

Take this 300-hp. engine with 30 lb. of steam per horsepower-hour. Assuming the steam at 2 lb. back pressure, we have a specific volume of the steam of 23.8 cu.ft. The area of the 8-in. separator is 50.266 sq.in., or 0.349 sq.ft. The velocity of steam through the separator per minute will then be $\left(\frac{300 \times 30 \times 23.8}{60}\right) \div 0.349 = 10{,}229$ ft. per min. When the change was made to a 12-in. separator the area was increased from 0.349 sq.ft. to 0.785 sq.ft., thereby decreasing the velocity of steam per minute to $\left(\frac{300 \times 30 \times 23.8}{60}\right) \div 0.785 = 4548$ feet.

It is well known that the separation of oil from steam cannot be done unless there is a quantity of water present in the steam. The water acts as a carrier in removing the oil. Each drop carries a thin film of oil on the outside. With the velocity of 10,229 ft. per min. through the 8-in. separator, this water carrying the oil would strike the baffle plates with such a tremendous force that it would be shattered into an exceedingly fine mist, would rebound from the surface, would be picked up by the flow of steam and would be carried around the baffle.

By changing to a 12-in. separator the velocity was decreased to practically 4548 ft. per min. At this speed, the impact on the baffle would not be great enough to disintegrate the oil and water into a fine spray, and the blanketing effect of the steam would not be overcome to such an extent but that the water would run down the baffle to the storage well below and separation would take place.

My experience, covering several hundred installations of similar character, indicates clearly that the wrong type of separator was installed to handle this work. An 8-in. separator of the centrifugal type properly designed would have made the conditions as outlined in the article impossible and would have given better separation than was obtained with the 12-in. separator of the other type. This would have resulted in a saving of 40 to 50 per cent. in purchasing a separator, not to mention the extra expense of installing the 12-in. connections. R. J. PABODIE.

Chicago, Ill.

It is probable that Mr. Wakeman's trouble could have been eliminated in a much cheaper way by installing a separator of different design. While an allowance of 90 lb. per sq. in. per hour may be correct for the single-baffle type of separator, the multiple-baffle type has shown itself to have a much larger capacity. This type usually has baffles that have a comparatively large area relative to the exhaust-pipe area, and consequently the steam has a much lower velocity over the baffles than in the case of the single-baffle type.

The allowance of 90 lb. per sq.in. per hour is considerably less than is usually found in ordinary plants. A 50-hp. horizontal engine would have about a 4-in. exhaust connection. Assuming a steam consumption of 35 lb. per hour, the flow of steam through the pipe would be at the rate of about 139 lb. per sq.in. sectional area per hour. As many separators are giving good service under approximately these conditions, it would seem that the 90 lb. allowance is rather low—for the smaller sizes at any rate. D. F. GRAHAME.

Ottawa, Ont., Canada.

Avoiding Unnecessary Pumping

W. T. Meinzer, in his article, "Avoid Unnecessary Pumping," page 220 of the Feb. 11 issue, doubtless unintentionally forgot to mention one point. In most cities the water pressure will vary. It will be boosted up to around eighty pounds in case of fire and in up-to-date cities is raised for a short while during the night for testing purposes.

Under such a condition, with plunger pumps, a pounding would probably be caused, but it could be easily overcome by throttling the suction. In the case of centrifugal pumps, especially when driven by direct-current motors, the case is different.

Unless otherwise specified, the majority of manufacturers ship their pumps equipped with motors that are figured to be large enough to do the work required of them, provided the pumps take from a suction tank having a maximum head and no more. Coupling the city-water main direct to such a pump would greatly increase the pump's capacity, causing the motor to be overloaded, and sooner or later create an electrical breakdown that would be annoying to say the least.

Winnipeg, Man., Canada. O. PETTERSSON.

If Old Glory means anything to you, buy Victory Liberty Loan Notes.

Inquiries of General Interest

Current at Unity Power Factor—When a 1500-kw. 600-volt, three-phase alternator is operating at full load and unity power factor, what should each ammeter read if the load is balanced? E. M. C.

The reading of each ammeter should be the same and is equal to the kilowatt rating of the machine times 1000, divided by 1.732 times the volts, which in this problem is $(1500 \times 1000) \div (1.732 \times 600) = 1443$ amperes.

2200-Volt Motor on 440 Volts—What horsepower would a three-phase 50-hp. 2200-volt 750-r.p.m. motor develop if connected on a 440-volt line? P. F. M.

Theoretically, one-fifth of 50, or 10, hp. and the starting torque would be 1/25 of that at 2200 volts. The only thing to do is to reconnect the stator winding for 440 volts. Just what the grouping should be cannot be determined without knowing the number of coils and how they are grouped in the 2200-volt winding. If the 2200-volt winding is connected in series star, which is probably the case, then the 440-volt winding may be connected 5-parallel star. However, if the number of coils per phase cannot be divided by 5 it may be somewhat of a problem to distribute the coils so as to get a satisfactory winding. A 3-parallel delta connection might be found to give a more satisfactory grouping. This gives an equivalent 418-volt winding, which is close enough to 440 volts to operate satisfactorily.

Short-Circuited Wound Rotor—We have a 150-hp. 2200-volt three-phase 25-cycle motor. The rotor is wound and is rated at 263 volts and 245 amperes. Would it be possible to short-circuit the rotor leads and start the motor under about one-half rated load, with a compensation? P. F. M.

With the slip rings short-circuited the rotor may develop considerable starting torque if the winding has a comparatively high resistance. However, at best it is liable to develop locking points and, if the resistance of the rotor's winding is low, may give trouble to start a load requiring only a small starting torque. If it is necessary to use a compensator to start the motor with, instead of a resistance in the rotor circuit, better results could be obtained by short-circuiting the rotor conductors on rings at each end of the core, thus converting the machine into one of the squirrel-cage type. However, at best this is only a makeshift and is liable to give trouble. If satisfactory operation is to be expected of a motor of this size and voltage, it should be started in the way it was designed to be; namely, with an external rotor resistance.

Raising the Pressure of a Heating Boiler Without Increasing Its Capacity—A low-pressure steam-heating plant, operated with 15-lb. boiler pressure, is equipped with two boilers capable of carrying 100-lb. pressure, and during most of the heating season one boiler is sufficient. Could not the capacity be materially increased by generating the steam at 30- to 40-lb. pressure and supplying the system with the steam reduced to a pressure of 15 lb. per sq.in., by means of a pressure-reducing valve? A. J. C.

The heating capacity of a boiler depends on the amount of heat liberated by combustion of the fuel and received by the boiler. The same forcing of the boiler could result in liberation of only the same amount of heat, and by carrying a higher boiler pressure, the temperature of the boiler water and of the heating surfaces would be higher, and from that cause there would, if anything, be transfer of less heat of the fire. Hence the heating capacity could not be increased by raising the boiler pressure. Operation of the apparatus as a gravity return system at 15-lb. pressure and higher pressure on the boiler would necessitate the expenditure of steam or power for operating a pump or some other form of boiler feeder.

Resetting Valves to Change from Condensing to Noncondensing—What changes should be made in the valve setting of a Corliss engine if a change is made from running condensing to noncondensing? A. H.

When running noncondensing the exhaust will be at higher pressure, and for smooth running of the engine the necessary cushioning on the exhaust can be obtained by less compression, obtained by closing the exhaust valves later in the stroke. On a single-eccentric engine, set the eccentric back on the shaft so that only the necessary compression of exhaust is obtained, and see that the exhaust-valve rods are short enough to obtain release before the end of the expansion stroke. Setting the eccentric backward will delay admission and the steam-valve rods will need to be shortened so the valves will have less lap and proper lead. With the wristplate hooked in gear, place the engine first on one center and then on the other and adjust the valve rods to suitable lengths for obtaining the proper lead and release. With a double-eccentric engine, setting of the steam eccentric and steam-valve gear needs to be no different than when running condensing, and for less compression of the exhaust, the exhaust eccentric and exhaust-valve gear would require the same attention as the valve gear of a single-eccentric engine, but omitting all consideration of the steam valves and their rods.

Cylinder Clearance of Air Pump—What is the greatest percentage of cylinder clearance permissible for an air pump to obtain 29¾ in. vacuum? J. C. A.

When referred to the standard atmospheric pressure of 30 in. of mercury column pressure, 29¾ in. vacuum would be equal to an absolute pressure of $30 - 29.75 = 0.25$ in. of mercury-column pressure. At a constant temperature the volume of a given weight of air is inversely as its absolute pressure. Calling the piston displacement of the air pump D and the clearance percentage c, when 29.75 in. vacuum is attained at the end of a suction stroke, the volume of air contained in the cylinder and clearance space would be $D(1 + c)$. During the return stroke the air cannot be discharged until it has been compressed to the pressure of the atmosphere or an absolute pressure of 30 in. of mercury column. Calling the volume at atmospheric pressure v, then as

$$v : D\ (1 + c) :: 0.25 : 30,$$

$$30v = 0.25D\ (1 + c) = 0.25D + 0.25Dc$$

from which

$$v = \frac{0.25D + 0.25Dc}{30}$$

If $v = Dc$, then by substitution

$$Dc = \frac{0.25D + 0.25Dc}{30}$$

from which $c = 0.0084$.

But when $v = Dc$ no discharge can take place, for if the air has not been compressed a little above atmospheric pressure before the volume is compressed to the clearance volume Dc (that is, before the piston reaches the end of the stroke), it cannot be discharged against the pressure of the atmosphere. For the condition the air would be compressed into the clearance space at or slightly above the pressure of the atmosphere and, during the succeeding suction stroke, no more air at 29.75 in. vacuum could be drawn into the cylinder, for the clearance air could not reëxpand to a lower pressure than it had at the beginning of the compression stroke. Hence, barely nominal capacity would be obtainable for 29.75 in. vacuum with the clearance more than $\frac{84}{100}$ of 1 per cent., and for any degree of vacuum the larger the free air capacity the smaller the percentage of clearance required.

Aims and Organization Committee of the Mechanical Engineers

Some thirty members of the Committee on Aims and Organization of the American Society of Mechanical Engineers met at Galen Hall, Wernersville, Penn., on Thursday, Friday and Saturday, Apr. 24-26, to consider methods for broadening the scope of the society's activities, improving its efficiency and increasing the service which it can render to the community.

It would be premature to discuss in detail, before their submission to the Council, the various measures proposed for the purpose of improving the relations of the engineer to his work, to the community and to other engineers. The spirit manifested was progressive, and the recommendations of the various subcommittees such as, if adopted, to relieve the society of any shadow of opportunity for the application of criticism to which the national professional societies in general have been subjected on the ground of old-fogyism, inertia and self-satisfied complacency. The results of the three-days' discussion will be reduced to concrete form and presented for discussion at the spring meeting at Detroit.

N. E. L. A. Will Meet at Atlantic City

The National Electric Light Association will hold its 42nd convention in Atlantic City, May 19-22. On Tuesday morning, May 20, the first general and executive session will be held. The proceedings will be opened by an address of welcome to the city by Mayor Harry Bacharach, followed by an address by the president of the association, W. F. Wells, of the Brooklyn Edison Co., Inc. Reports as follows will then be given: Report of the acting secretary, S. A. Sewall; report of the Rate-Research Committee, by Chairman Alex Dow; progress report of Special Joint Committee on "Determination of Power Factor in Polyphase Unbalanced Circuits," by Chairman R. J. McClelland. In the evening the second general and executive session—The Public-Policy Session—will be held, at which the following reports and address will be made: Report of Public-Policy Committee, by Chairman W. W. Freeman; report of the National Committee on Gas and Electric Service, by Chairman J. W. Lieb; address on "The Trend of Socialism," by F. G. R. Gordon.

The Accounting Section will hold its first session on Tuesday afternoon and its second session on Wednesday afternoon. The Commercial Section will hold its first session on Tuesday afternoon; its second, third and fourth sessions on Wednesday afternoon and its fifth on Thursday. Among the many reports, discussions and papers at these sessions will be the following: At the third commercial session there will be a discussion on the "Effect of the War on Isolated Plant Costs," led by I. Lundgaard; "Digest 1917 Report of Electrical Heating Bureau — Electrical Heating of Nonferrous Metals," by C. F. Hirshfeld; and a paper on "Power Factor in Customers' Installations," with discussion led by R. H. Knowlton. At the fourth commercial session there will be discussion on "Electric Welding," led by F. E. Richards. The Electric Vehicle Section will hold its first session on Tuesday afternoon and its second on Wednesday afternoon. The Technical and Hydro-Electric Section will hold its first and second sessions on Tuesday afternoon and its third on Wednesday. The first session will be opened with an address by the section chairman, R. J. McClelland, followed by a report of the Committee on Prime Movers, by Chairman N. A. Carle. The second technical session will open with a report of the Committee on Underground Construction and Electrolysis, by Chairman E. B. Meyer, followed by a report of the Committee on Overhead Lines and Inductive Interference, by Chairman A. E. Silver. The third technical session will open with a report of the Committee on Electrical Apparatus, by Chairman R. F. Schuchardt, followed by a report of the Committee on Meters, by Chairman F. V. Magalhaes.

The third general and executive session will be held on Wednesday morning and among various reports will be an address on "Regional Power Systems," by George Otis Smith. The fourth general and executive session will meet on Thursday morning, opening with a report of Committee on Safety Rules and Accident Prevention, by Chairman William C. L. Eglin. This will be followed by various other reports.

William T. Wheeler

William T. Wheeler, president of the Diamond Carbonating Co., Inc., New York City, died suddenly at his home in Brooklyn, of acute indigestion on Apr. 26. Mr. Wheeler was born in Calais, Me., 52 years ago. He was for some years connected with the Trinity Engineering Co., later first assistant engineer of the Equitable Life Insurance Co. and chief engineer of the New York Life Insurance Co. He was a well-known construction engineer and was very popular. He was a past president of the National Association of Stationary Engineers and was also a member of the American Society of Mechanical Engineers. He was a member of the Jamaica Bay Yacht Club, Brooklyn Lodge of Elks, No. 22, Scottish Rite, past master of Joppa Lodge, No. 201, of Brooklyn, a former commander of Damascus Commandery, a member of the Kismet Temple, Nobles of the Mystic Shrine, and was formerly grand steward of the Masonic Grand Lodge of the State of New York.

WILLIAM T. WHEELER

Personals

T. J. Hudson, of the Chicago Pneumatic Tool Co. has been appointed acting manager of the Pneumatic Tool Sales Division, to succeed F. H. Waldron, who returns to Minneapolis, Minn., as district manager of sales for the Minneapolis territory.

F. W. Fischer, who has been assistant power superintendent of Du Pont Engineering Co., at Wilmington, Del., has been appointed mechanical superintendent in charge of the power, electric and maintenance divisions of Old Hickory Powder plant at Nashville, Tenn. Mr. Fischer was formerly assistant master mechanic of the Muscle Shoals plant in Alabama.

Obituary

William F. McDonald, president of the Wm. F. McDonald Co., Detroit, Mich., died suddenly at his home in same city on Apr. 25. Mr. McDonald was secretary of the Michigan Chapter of the American Society of Heating and Ventilating Engineers, chairman of the Committee on Increase of Membership, and member of the Committee on Research, and his loss by the Society will be keenly felt. He was 42 years of age.

Engineering Affairs

Kansas State Association, N. A. S. E., will hold its convention at Topeka, May 7-9.

The New York Chapter of the American Association of Engineers met at the United Societies Building, Wednesday, Apr. 23. The principal speaker was Robert M. MacBride, a publisher and journalist, who went to Europe with the party of journalists, and visited the battlefields of France and occupied Germany. The next meeting will be held May 14, when the newly elected officers will be installed.

The Chicago Sections of the American Institute of Electrical Engineers and the Association of Iron and Steel Electrical Engineers will hold a joint meeting on May 26, at which J. C. Wilson, assistant chief engineer of the Cutler-Hammer Manufacturing Co., will give a lecture on "Measuring Gas Electrically," and B. E. Fernow, of the same company, will lecture on "Lifting Magnet Operation." Both lectures will be illustrated.

Massasoit Association No. 2, N. A. S. E., of Springfield, Mass., held its annual banquet at the Highland Hotel, on Saturday, Apr. 26. The main hall was filled to capacity, and tables were set in an adjoining room to accommodate the overflow The speakers included F. R. Low, of "Power"; Walter H. Damon, George Madsen, Claude Allen, of Garlock Packing Co.; Harry Mantham, W. J. Reynolds, J. H. Henderson and others. The entertainment was furnished by the Ladies Des Rosierses Trio; L. H. Serre, of Jenkins Bros.; Bob Jones, of the France Metallic Packing Co., and Jack Armour, of "Power." Herbert E. Stone was the toastmaster.

The Iowa National Association of Stationary Engineers will hold its annual state convention at Marshalltown, Iowa, June 11-13. The following papers and talks will be given at the convention: Lantern talk on "The Uniflow Engine"; movie talk on "Iron from the Mine to the Tube"; talks on "Flow Meters"; "Isolated Plants"; "James Watt"; "Development of the Steam Gage"; "Plant Operating Economies." Arrangements have been made for visits to many large plants. There will be a banquet on the evening of the closing day at the Pilgrim Hotel, the headquarters of the convention, at which Prof. W. H. Meeker, of the Iowa State College, will be the principal speaker.

The American Society of Mechanical Engineers will hold its spring meeting in Detroit, June 16-19, with headquarters at the Hotel Statler. The tentative program is as follows: Monday, June 16: Registration in forenoon; business meeting in afternoon; followed by a general meeting at which the Committee on Aims and Organization will make a report; informal reception at the hotel in the evening. Tuesday: Research session in the morning and Industrial Relations session in the afternoon; social in the evening. Wednesday: Morning session in charge of Detroit Local Committee and a Miscellaneous session; afternoon and evening, boat trip and dinner on the Lake. Thursday: Gas Power and Miscellaneous sessions in the morning; excursions in the afternoon.

The American Association of Engineers will hold its annual meeting at the Hotel La Salle, Chicago, May 12-13. The first morning will be devoted to registration and reports of officers and standing committees, followed by a discussion on the "Relation of Other Societies to the American Association of Engineers" and "The Relation of Engineers to Each Other in Employment." In the afternoon Prof. F. Bass, of the University of Minnesota, will talk on "How the Curricula of Engineering Colleges Shall Be Modified to Meet Modern Conditions." On May 13 the following papers will be presented at the morning session: "Proper Compensation of Engineers—Ways and Means of Obtaining It—Recognition Through Self-Improvement and Service"; "The Engineer in Politics"; "Action on Behalf of the Engineers in Public Service." In the afternoon the discussion will be on "Employment and Opportunities," followed by business session, dinner and social to finish.

Business Items

The Bowers Rubber Works, San Francisco, Calif., has changed the name of the company to the Pioneer Rubber Mills.

The Chicago Pneumatic Tool Co. announces the election of Allan E. Goodhue as managing director if its English subsidiary, the Consolidated Pneumatic Tool Co., Ltd., whose offices are at 170 Piccadilly, London, and whose plant is in Fraserburg, Scotland. Mr. Goodhue will also be in charge of European sales for the Chicago Pneumatic Tool Co. He was for a number of years connected with the sales department of the Midvale Steel Co. and Midvale Steel and Ordnance Co. in Philadelphia, Chicago and Boston, leaving that company in March, 1918, to enter the service of the Government as assistant manager of the Steel and Raw Material Section, Production Division, of the Emergency Fleet Corporation.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.35
Philadelphia, gross tons	4 20@4.90	5 00@5 40
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7 65

Pocahontas and New River are quoted at $4 70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5 95	$7 80	Pea	4 80	6 55
Egg	5 85	7 70	Buckwheat	3 40	5 15
Stove	6.10	7 95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.80 @ 3.10	2.95 @ 3.25
Clearfield County	2 65 @ 2 95	....
Reynoldsville	2.65 @ 2.85	2.85 @ 2.95
Quemahoning	2 75 @ 2.95	2.95 @ 3 10
Somerset County (best grades)	2 75 @ 2 95	2 95 @ 3 10
Somerset County (poorer grades)	2.25 @ 2.50	2.50 @ 2.75
Western Maryland	2 25 @ 2 75	2.50 @ 2 75
Fairmont	2 10 @ 2 35	2 35 @ 2 50
Latrobe	2.10 @ 2.25	
Greensburg	2.35 @ 2.40	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6.10	7.95	Boiler	2.50	3.50
Nut	6 20	8 05	Barley	2 25	3 15
Pea	4 80	6 40	Culm	1.25	2 15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2 45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3 85@$4 50
Corona	3.40
Jagger	3 50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2 75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2 25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2 30	....
2-in lump	....		2.15

Williamson-Franklin rate to St. Louis is $1.07½: other rates 92½c.

New Construction

PROPOSED WORK

Conn., Naugatuck—The Y. M. C. A. Rockwell Ave., will install a steam heating plant in the 3-story building which it plans to build on Church St. Total estimated cost, $175,000. L. W. Jallade, 37 Liberty St., New York City, Arch.

Conn., Waterbury—The Board of Education plans to install a steam heating plant in the addition which it plans to build to Croft St. School. Total estimated cost, $125,000. L. A. Walsh, 50 Leavenworth St., Arch.

N. Y., Amsterdam—The Adirondack Electric Power Corp., 30 East Main St., plans to build a transmission line from here to Little Falls. C. O. Wilson, Supt.

N. Y., Brooklyn—The Brooklyn Hebrew Home & Hospital for the Aged, Howard and Dumont Aves., will install a steam heating plant in the 4-story, 90 x 100 ft. home and hospital addition which it plans to build. Total estimated cost, $100,000. L. A. Abramson, 220 5th Ave., New York City, Arch.

N. Y., Brooklyn—The Cairns Holding Co. Inc., c/o the Gillies Campbell Co., Contractors, 101 Park Ave., New York City, will install a steam heating system in the 9-story, 75 x 119 ft. factory which it plans to build on Atlantic Ave. and Classon St.

N. Y., Brooklyn—The Levy Bros., 189 Montague St., will install a steam heating plant in the 2-story, 130 x 180 ft. theater which they plan to build on Bedford Ave. and Lincoln Rd. Total estimated cost. $500,000.

N. Y., Brooklyn—The Washington Amusement Co., c/o Zipkes, Wolff & Kudroff, Arch., 25 West 42nd St., New York City, will install a steam heating plant in the 1½-story, 100 x 137 ft. theater which it plans to build on Washington Ave. and Prospect Pl. Total estimated cost, $100,000.

N. Y., Cohoes—The Board of Education will install a steam heating plant in the 3-story high school which it plans to build. Total estimated cost, $210,000. Tooker & Marsh, 101 Park Ave., New York City, Engr.

N. Y., Far Rockaway—B. S. Moss, 729 7th Ave., New York City, will install a steam heating plant in the theater which he plans to build on Mott Ave. and St. James St. Total estimated cost, $250,000. De Rosa & Pereira, 110 West 40th St., New York City, Arch.

N. Y., Geneseo—L. F. Pilcher, State Arch., will soon receive bids for remodeling and building an addition to the heating and ventilating systems at the Geneseo Normal School here. $60,000 available for the project. Address J. V. Sturges, Principal.

N. Y., Glen Falls—The Arrow Grip Manufacturing Co. has increased its capital stock from $100,000 to $500,000 and will install power, heating and special machinery in the factory which it plans to build on land adjoining the Delaware & Hudson R. R. Total estimated cost, $150,000.

N. Y., Iroquois—The Board of Managers. Thomas Indian School, plans to install refrigeration equipment for the ice house, also dairy room and cold storage building and ammonia system. W. Hunt, Pres.

N. Y., Long Island City—The Louraine Magneto Co., Bridge Plaza, has awarded the contract for the construction of a 3-story, 100 x 150 ft. factory on 13th St., near Van Alst Ave., to the Northeastern Supply Co., Harris Ave. A steam heating system will be installed in same. Total estimated cost, $125,000.

N. Y., New York—The Terminal Warehouse Co., 17 South William St., will install a steam heating plant in the 2-story warehouse which it plans to build at 29-31 South William St. Total estimated cost, $100,000. J. W. O'Connor, 3 West 29th St., Engr.

N. Y., Rochester—The Whit-Field Map Co. Inc. will install power and special machinery in the factory which it plans to build. Estimated cost of machinery and power from $25,000 to $35,000. Address I. A. Whitman, Rochester.

N. Y., Watertown—The Northern New York Utilities Co. Inc., Light & Power Bldg., plans to build a transmission line from Watertown to Brownville and replace the present 3,000 volt current with one of 22,000 volts. Electrical equipment, including transformers, etc., will be required for same. H. G. Davis, Ch. Engr.

Penn., Tamaqua—J. C. M[illegible], Tamaqua, and J. L. [illegible], Patterson, have leased from the Lehigh Coal & Navigation Co. the property on which they plan to build a 1-story, [illegible] ft. factory for making ice and ice cream. Estimated cost, $100,000.

D. C., Washington—The George Washington Memorial Assn., [illegible] Scott Circle, will install a steam heating plant in the 1-story, [illegible] ft. memorial building which it plans to build. Total estimated cost, $1,000,000. Tracy & Swartwout, 18 West 34th St., New York City, Engr.

Ga., Columbus—The Eagle & Phenix Mills, Front St., plans to build a new power house. Lockwood, Greene & Co., Healey Bldg., Atlanta, Engr.

Fla., Jacksonville—The Atlantic National Bank will install a steam heating plant in the 1-story, 50 x 100 ft. bank which it plans to build. Total estimated cost, $100,000. Mowbray & Uffinger, 56 Liberty St., New York City, Engr.

Ohio, Akron—The Goodyear Tire & Rubber Co., Market St., will install a steam heating plant in the 4-story welfare building which it plans to build. Total estimated cost, $100,000. Walker & Weeks, 1900 Euclid Bldg., Cleveland, Arch.

Ohio, Cleveland—The Cleveland Automobile Co., East 131st St. and St. Clair Ave., plans to build a 4-story boiler house on London Rd. Estimated cost, $100,000. E. McGeorge, 1900 Euclid Ave., Arch.

Ohio, Cleveland—The Cream Cone Machine Co., 1836 Euclid Ave., has awarded the contract for the construction of a 3-story, 60 x 100 ft. factory on East 59th St. and Hough Ave. to the A. A. Lane Construction Co., 1836 Euclid Ave. A steam heating plant will be installed in same. Total estimated cost, $100,000.

Ohio, Cleveland—Paul Bros., Citizens' Bldg., will install a steam heating system in the 11-story office building which they plan to build on East 6th St. and Vincent Ave. Total estimated cost, $750,000. G. A. Grieble, Sloane Bldg., Arch.

Ohio, Waverly—The city has appropriated $11,000 for all necessary electrical equipment for lighting the town. Address the City Clk.

Ind., Attica—The Neal Gravel Co., Indianapolis, plans to double the capacity of its present gravel output which will necessitate the purchase of new engines, boilers, crushers, screeners, gravel removing equipment and possibly a new steam shovel.

Ind., Vevay—The Board of Commissioners plan to install a complete steam heating system in Court House.

Mich., Detroit—The Alfred Street Jewish Congregation will install a steam boiler in the 2-story, 55 x 76 ft. synagogue which it plans to build on Alfred St. Total estimated cost, $50,000. R. Finn., 1144 David Whitney Bldg., Arch.

Mich., Detroit—H. Kramer & Sons, 1697 Gratiot Ave., will install a complete steam heating plant consisting of boiler, fans, motor driven air compressor, etc., in the 2-story, 80 x 230 ft. theatre and stores which it plans to build on Michigan Ave. between Bushey and Greusel Ave. Total estimated cost, $750,000. C. H. Crane and E. G. Kiehler, 2425 Dime Bank Bldg., Archts.

Mich., Detroit—St. Ambrose Parish, Wayburn Ave., will install complete steam heating apparatus in the 2-story, 75 x 100 ft. school which it plans to build on Wayburn Ave. and Alter Rd. Estimated cost, $100,000. Donaldson & Meier, 1314 Penobscot Bldg., Arch.

Ill., Chicago—The Fourteenth Church of Christ Scientist, c/o N. M. Dunning, Arch., 310 South Wabash Ave., will install a steam heating plant in the 1-story, 105 x 140 ft. church which it plans to build on Pauline and Sunnyside Ave. Total estimated cost, $175,000.

Ill., Chicago—Schmidt, Garden & Martin, Archts., 104 South Michigan Ave., are receiving bids for the construction of a 3-story ice factory on Lake Park Ave. and 24th St. for the Hydrox Co., 3543 Normal Ave.

Ill., Chicago—The Sixteenth Church of Christ Scientist, 1700 Lunt Ave., will install a steam heating plant in the 1-story, 100 x 160 ft. church which it plans to build on Ashland and Kenilworth Ave. Total estimated cost, $200,000. H. S. Cheney, 208 South La Salle St., Arch.

Ill., Forest Park—Carelin & Manos, c/o O. P. Speyer, Arch., 6507 Greenview Ave., Chicago, will install a steam heating plant in the 3-story, 75 x 125 ft. theater, store and apartment which they plan to build on Madison and Harlem Ave., Total estimated cost, $150,000.

Wis., Kiel—The village is in the market for a deep well pump, a 35 hp. electric motor and air compressors for power plant.

Wis., Wyocena—The Columbia County Electric Light & Power Co. will install motors for running an electric feed and flour mill. Address J. Figor, Jr.

Minn., Altura—The Power Engineering Co., 510 Corn Exchange, Minneapolis, plans to build a light and power plant here, to supply the villages and towns. Estimated cost, $300,000.

Minn., Duluth—The Board of Education, Glencoe Bldg., will install a steam heating and ventilating system in the school which it plans to build on Riverside Townsite. Total estimated cost, $110,000. C. A. Bromson, Secy. Croft & Boerner, Lansdale Bldg., Engr.

Minn., Minneapolis—The Northwestern Catalogue Co., 800 Phoenix Bldg., will install a steam heating plant in the 4-story, 100 x 100 ft. warehouse which it plans to build. Total estimated cost, $100,000. Long, Lamoreaux & Long, 1028 Andrus Bldg., Arch.

Mo., Carondolet (St. Louis, P. O.)—The Mineral Refining & Chemical Corp. will receive bids about June 1 for the construction of a paint and pigment plant on the Mississippi River front. Plans include power plant, packing plant, etc. Estimated cost, $2,500,000. M. Alayo, Vice-Pres.

Mo., St. Louis—The C. Nelson Manufacturing Co., 2300 Division St., is in the market for several electric motors, planers, saws and woodworking machinery.

Cal., Redwood—The city plans election soon to vote on bonds for the construction of 7 bridges, a sewage pumping plant and a macadam road leading to the pumping station. C. E. Dimmick, City Engr.

N. S., Clarks Harbour—The Town Council is having plans prepared for the installation of an electric light plant. Estimated cost, $60,000.

Que., Three Rivers—The Canadian Pacific R.R., Windsor St., Montreal, will soon receive bids for electrifying branch line from Three Rivers to Shawenegan Falls and Grand Mere. J. M. Fairbairn, Ch. Engr.

Ont., Galetta—The Galetta Electric Power Co., Arnprior, plans to extend their lines from Galetta to Arnprior. J. R. Dodd, Arnprior, Gen. Supt.

Ont., London—A. Deviney, St. Marys, is in the market for a steam engine, boiler, etc., to be installed in the flax mills which ne plans to build. Total estimated cost, $50,000.

Ont., Sarnia—W. D. Ferguson and J. McCutcheon have purchased a building at 313 Front St., and will remodel same for a cold storage plant. Estimated cost, $25,000.

Ont., Welland—The city plans to build an ice plant. Estimated cost, $35,000.

CONTRACTS AWARDED

N. Y., Rockaway—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a pump house for electric remote control gasoline system at the Naval Air Station here, to C. Mead & Co., 38 Park Row, New York City. Estimated cost, $1,664. Noted Apr. 29.

N. Y., Westfield—Armour & Co., 208 South La Salle St., Chicago, Ill., has awarded the contract for rebuilding its 3-story, 130 x 200 ft. factory and 54 x 54 ft. power house, destroyed by fire, to the Black Construction Co., 20 West Jackson Blvd., Chicago, Ill. Estimated cost, $210,000.

Md., Baltimore—The city has awarded the contract for furnishing and erecting a 30,000,000 gallon turbo-centrifugal pump and auxiliary equipment to be installed at the Mount Royal Pumping Station, North Ave. and McMechen St., to the Worthington Pump & Machine Corp., 115 Broadway, New York City. Estimated cost, $26,258. Noted Dec. 24.

Fla., Pensacola—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for power plant improvements here, to the Carroll Electric Co., 714 12th St., Washington, D. C. Estimated cost, $54,500 (150 days).

Ohio, Cincinnati—The Dolly Varden Chocolate Co., 411 Laurel St., has awarded the contract for the construction of a 6-story, 53 x 100 ft. candy factory, to the Ferro Concrete Construction Co., Richmond and Harriet St. A 60-ton carbon-dioxide refrigerating system and a 150 hp. boiler will be installed in same. Estimated cost, $80,000.

Minn., Cloquet—The Board of Education has awarded the contract for installing a heating system in the high school, here, to H. Gazett, 423 Superior St., Duluth. Estimated cost, $28,600.

Opportunities!

CONTRACTS

Contracts to be let for furnishing Boilers, Stokers and Drivers.

POSITIONS

For Mechanical and Electrical Engineers, Superintendents, Chief Engineers, Salesmen, etc. —and men for like positions.

TO SELL

TO BUY

Advertisements of equipment wanted to purchase —of equipment offered for sale at bargain prices.

All these "Opportunities" appeared in *last* week's issue. You will find those offered *this* week on pages 83 to 90.

PRICES - MATERIALS - SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft. Lengths
Underwriters' 2½-in	70c. per ft.
Common, 2½-in	40%

Air	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.50	$0.35	$0 25

Steam—Discounts from List

First grade 30% Second grade 40% Third grade 40 10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition 60% Best grade 35%
Standard 50%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	45%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	35%	35%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0 90
Asbestos for high-pressure steam	1 60
Duck and rubber for piston packing	1 00
Flax, regular	1.20
Flax, waterproofed	1 60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1 20
Asbestos wick, ½- and 1-lb. balls	85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1 10	3 -in.	90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure		List
For low-pressure heating and return lines	4-ply	58% off
	3-ply	60% off
	2-ply	62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5½	7 2	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	8½	20
Axle	4½	6	4	4.75	4½	5½
Gear	4½	9	4½	7.5	8½	8
Car journal	22(gal.)	21 (gal.)	3½	4.9	8½	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11.00 to 13.00	13.00	16.50	12.00 to 16.50
Colored mixed	8 50 to 12 00	12 00	13 00	11.50 to 14 00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$52 00	$58 00
Chicago	48 00	50 00

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Raw in barrels	$1 55	$1 55	$1 68	$1 65	$1 66	$1 65
5-gal cans	1 70	1 65	1 85	1 80	1 86	1 75

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13 00	14 50	11 25	11 50	13 00	10 50
25- and 50-lb. kegs	13.25	14.75	11 50	11 75	13 25	10 75
12½-lb keg	13 50	15 00	11 75	11 00	13 50	11 00
1-lb. cans	15 00	16 50	13 25	13 00	15 00	13 00
5-lb. cans	16 00	17.50	13 25	13 50	16 00	13 00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. car boys, is 11c.; in 1000-lb. drums, 9c

RIVETS—The following quotations are allowed for fair-sized orders from warehouse.

	New York	Cleveland	Chicago
Steel 7/16 and smaller	40%	60–5%	45%
Tinned	30%	60–5%	40%

Boiler rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$6 35 Cleveland...$4.75 Chicago...$4.72 Pittsburgh... 4.65

Structural rivets, same sizes:

New York....$6.25 Cleveland...$4.85 Chicago...$4 82 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00	at Chester, Penn.
Chrome cement	net ton	65.00	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48	at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50	at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90	at Chester, Penn.
Silica brick	net ton	45–55	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $45; silica, $50; magnesite, $85; chrome, $95.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL — Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	90.00	79.00	90.00	75.00	90.00
Commercial	42.00	50.00	18.50	30.00	15.00	30 00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.00
Chicago	16.50	15.00

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 15c. per lb.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft	7.65	6.85	6.10	6.85
7 in. by 35 ft	11.10	10 00	8.95	10 00
8 in. by 35 ft	12.65	11.35	10.10	11 35
7 in. by 40 ft	12.85	11.50	10 20	11 50
8 in. by 45 ft	18.90	16.90	15 00	16 90
8 in. by 50 ft	22.65	20.30	18 00	20 30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft	$9.00
12-in. butts, 6-in. tops, length 30-40 ft	11.50
12-in. butts, 6-in. tops, length 41-50 ft	12.50
14-in. butts, 6-in. tops, length 51-60 ft	21.00
14-in. butts, 6-in. tops, length 61-71 ft	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Steel Inches	Black	Galvanized	Iron Inches	Black	Galvanized
⅛ ¼, and ⅜	50½%	24%	¾ to 1½	39½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

Inches	Black	Galvanized	Inches	Black	Galvanized
2	50½%	38%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼ and ⅜	46½%	29%	¾ to 1½	39½%	24½%
½	51½%	39%			
¾ to 1½	55½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

Inches	Black	Galvanized	Inches	Black	Galvanized
2	48%	37½%	2	33½%	20½%
2½ to 4	51%	40½%	2½ to 4	35½%	23½%
4½ to 6	50%	39½%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	47%	31%	46½%	31%	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	42½%	27½%	51½%	41%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%.
Cast iron, standard sizes, 10% off

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in	40½	3½ to 4½ in	15½
2½ to 3¼ in	40½	3 to 3¼ in	1
2¼ in	[illegible]	2½ to 2¾ in	+ 1
1¾ to 2 in	[illegible]	2 to 2¼ in	+16
		1¾ to 1⅞ in	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in	$[illegible]	1¾ in	$207
1¼ in	[illegible]	2 to 2¼ in	177
1½ in	[illegible]	2½ to 3¼ in	167
1¾ in	207	4 in	187
		4½ to 5 in	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE

B &S Size	Two Cond M Ft	Three Cond M Ft	Two Cond Lead M Ft	Three Cond Lead M Ft
No 14 solid	$104 00	$138 00	$164 00	$222 00
No 12 solid	135 00	170 00	211.00	290 00
No 10 solid	185 00	235 00	255 00	325 00
No 8 stranded	235 00	325 00	345 00	450 00
No 6 stranded	370 00	472 00	625 00	

From the above lists discounts are:

Less than coil lots	Net List
Coils to 1,000 ft	10%
1,000 ft and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready

	Each, Net
Less than 12	$0 40
12 to 50	38
50 to 125 (bbl)	.35
125 (bbl.) or over	.32

CONDUITS ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In	Black 1,000 Ft and Over	Galvanized 1,000 Ft and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜	$71 15	$76 25	$17 04	$18 18	$5.38	$5.74
½	71 15	76 25	17.04	18 18	6 28	6.70
¾	93 96	100 86	22 43	23 93	8 97	9.57
1	138 39	149 09	33.19	35.41	11 66	12 44
1¼	187 91	201 71	42 62	45.31	16 10	17 12
1½	224 68	241 18	56 82	60.62	19 89	21.15
2	302 29	324 49	104.17	110 77	26 52	28.20
2½	477 95	513.05	170.46	181.26	37.88	40.28
3	625 00	670.91	454.56	483.36	56.82	60.42
3½	779 24	834.44	1,003 82	1,067.42	75.76	80.56
4	945 03	1,010.43	1,160.08	1,233.57	94.70	100.70

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ⅜ in., 100 ft. Standard lengths flexible, ½ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅛	250	$0.05½	Coils.....60% off Less coils, 50% off
¼	250	.06	
⅜	250	.09	
½	200	.12	
⅝	200	.15	
¾	150	.18	
1	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L	$0.11	T. P. to D. P. S. B	$0.24
D. P. M. L	.18	T. P. to D. P. T. B	.38
T. P. M. L	.26	T. P. S. B	.33
D. P. S. B	.19	T. P. D. B	.54
D. P. D. B	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L	$0 33	$0 84	$1.68
T. P. M. L	48	1 20	2.40
D. P. S. B	.42	1.05	....
T. P. S. B	81	1.80	....
D. P. D. B	78	2 10	....
T. P. D. B	1.35	3 60	....
T. P. to D. P. D. B	90	2.52	....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No 18 cotton twisted	$18.00
No. 16 cotton twisted	24 00
No. 18 cotton parallel	25.00
No. 16 cotton parallel	32 00
No. 18 cotton reinforced heavy	35 00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30 00
No. 16 cotton reinforced light	36 00
No. 18 cotton Canvasite cord	29 00
No. 16 cotton Canvasite cord	35 00

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp	100	$0.25
35-amp. to 60-amp	100	.35
65-amp to 100-amp	50	.90
110-amp. to 200-amp	25	2.00
225-amp to 400-amp	25	3 60
450-amp to 600-amp	10	5 50

600-Volt	Std. Pkg.	List
3-amp to 30-amp	100	.40
35-amp to 60-amp	100	.60
65-amp to 100-amp	50	1 50
110-amp to 200-amp	25	2 50
225-amp to 400-amp	25	5 50
450-amp to 600-amp	10	8 00

Discount		
	Less 1-5th standard package	30%
	1-5th to standard package	40%
	Standard package	52%

FUSE PLUGS, MICA CAP

0-30 ampere, standard package	$4 75 C
0-30 ampere, less than standard package	6 00 C

LAMPS—Below are present quotations in less than standard package quantities

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B Watts	Plain	Frosted	No. in Package	Mazda C Watts	Clear	Frosted	No. in Package
10	$0 35	$0 38	100	75	$0 70	$0 75	50
15	35	38	100	100	1 10	1 15	24
25	35	38	100	150	1 65	1 70	24
40	35	38	100	200	2 20	2 27	24
50	35	38	100	300	3 25	3 35	24
60	40	45	100	400	4 30	4 45	12
100	85	92	24	500	4 70	4 85	12
				750	6 50	6 75	8
				1000	7 50	7 75	8

Standard quantities are subject to discount of 10% from list Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list

PLUGS, ATTACHMENT—

		Each
Hubbell, porcelain No. 5406,	standard package 250	$0.24
Hubbell composition No. 5467,	standard package 50	.32
Benjamin swivel No. 903,	standard package 250	.20
Hubbell current taps No. 5638,	standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12 00	$14 00	$13 90	$25 00
12	13 25	15 70	18 05	30 70
10	18 30	21.00	23 85	41.50
8	25 54	28 60	32 70	56.77
6	...	......	51 40	..
4	......	......	70 00	..
2	......	......	101 80	...
1	......	......	131 86	...
0	......	......	160 00	...
00	......	......	193 50	.....
000	......	......	235.20	...
0000	......	......	288 60	...

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$11.00	$14.50	$30 40	$16 00	$21 00	$33 00	$10 95	$15.25	$27.75
10	19.20	25.70	49.00	27.20	31 00	69.00	20.25	24.25	46.90
8	26 95	34.25	67 00	38 00	42 00	78 00	27 60	32.60	...
6	43.90	46.20	.	. .	65 00	130 00	48 25	54.75	.....
4	62.35	65 15	.....	.....	93 00	..	66 90	73.75	.....
2	92 60	96 25	.....	.....	140 00	....	96.00	104.50	...
1	120.95	125 20	.....	.....	182 00	....	121.00	136.40	...
0	164.80	164 80	.....	.....	242 00	....	169.00	174.60	...
00	......	203 35	.....	.....	290 00	.....	203.50	214.00	.....
000	......	248 40	.....	.....	360 00	.....	246.00	257.50	.....
0000	......	302.55	.....	.....	435 00	....	295.50	358.50	.....

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap.			⅜ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	36c. lb.
No. 18 B.&S. regular 1-lb. coils	37c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1 20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1 36
60	74	1 22	1.84	2 44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9 00

TYPE "C" FUSIBLE, TOP OR BOTTOM

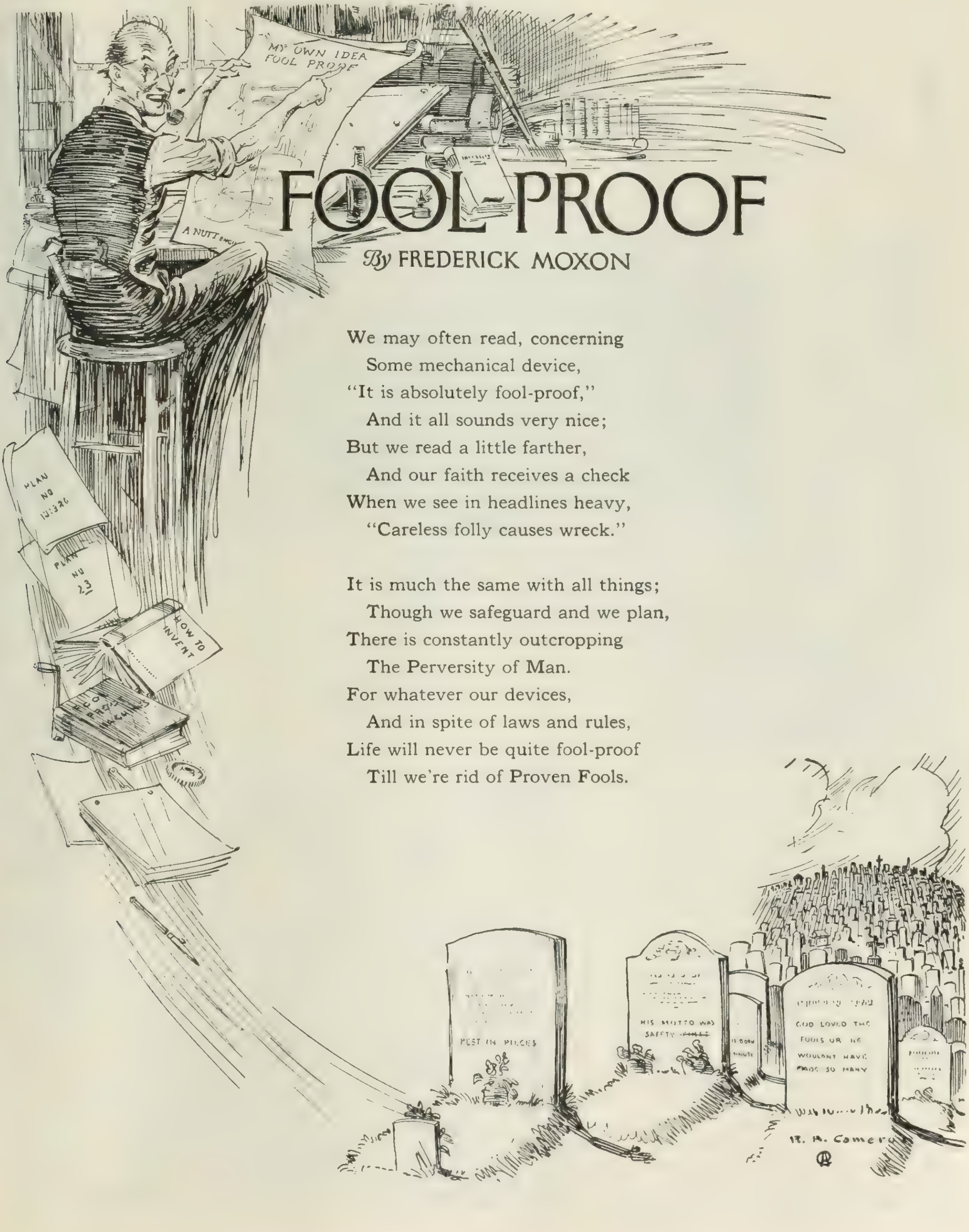
Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	.70	1.06	1.60	2.120
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.3
200	4.40	6.76	10 14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%

POWER

Volume 49 New York, May 13, 1919 *Number* 19



FOOL-PROOF

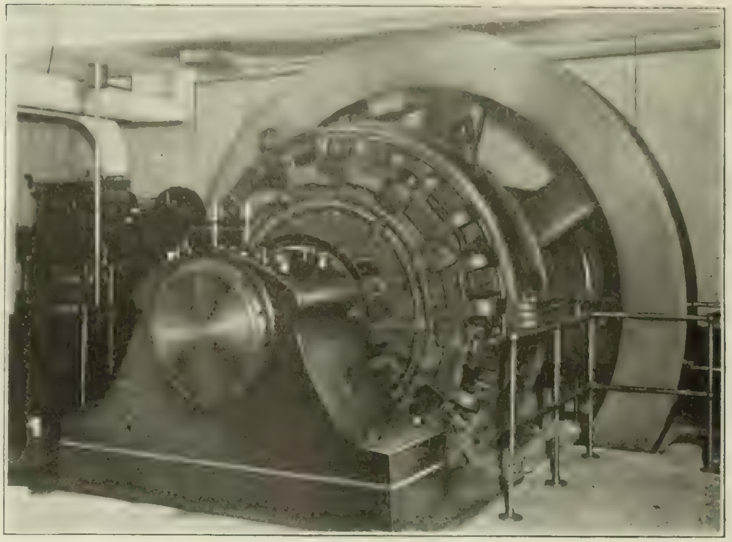
By FREDERICK MOXON

We may often read, concerning
  Some mechanical device,
"It is absolutely fool-proof,"
  And it all sounds very nice;
But we read a little farther,
  And our faith receives a check
When we see in headlines heavy,
  "Careless folly causes wreck."

It is much the same with all things;
  Though we safeguard and we plan,
There is constantly outcropping
  The Perversity of Man.
For whatever our devices,
  And in spite of laws and rules,
Life will never be quite fool-proof
  Till we're rid of Proven Fools.

Electric and Elevator Equipment of the Hotel Pennsylvania

By Chas. E. Knox,
CONSULTING ELECTRICAL ENGINEER, NEW YORK, N.Y.



THE outstanding requirement of the electrical and elevator equipment of a hotel is service. With the keen competition existing between the hotels today, it is mandatory that the guests be provided with every convenience in the way of lighting, signal systems and elevator service, so that their needs may be quickly satisfied. A brief description of how these requirements are met in the Hotel Pennsylvania, so far as the electrical equipment and elevator service are concerned, may therefore prove of interest.

Three possible sources of current supply were available for the new hotel: First, a private plant in the building; second, the Pennsylvania Railroad power plant; third, the New York Edison Co. In conjunction with the electric-current supply it was of course also necessary to take into consideration the question of the steam supply, and in studying the problem the two were necessarily considered jointly. All three sources of supply mentioned were therefore carefully considered, and a contract was finally made between the hotel operating company and the Pennsylvania Railroad for the supply of both steam and electricity.

It is estimated that approximately 225,000,000 lb. of steam and 5,000,000 kw.-hr. of electricity will be needed each year for the complete building.

There is no question that a private plant for a large hotel is usually more economical in the production of steam and electricity than the purchase of the steam and electricity supply, unless both could be purchased at a lower rate than the present rates filed with the Public Service Commission in the State of New York. In a large hotel, if anywhere, electricity can be produced at a very low rate, due to the great exhaust-steam requirements and also because a hotel is operated twenty-four hours a day 365 days in the year.

After a study of the cost of current production was made, a conclusion was reached that unless the current and steam could be bought at a lower price than the one filed by the Public Service Commission, a saving would be effected by the installation of a private plant. The New York Edison Co. was handicapped by the difficulty of supplying the amount of steam required. A suggestion was made by this company that the boiler plant in the Gimbel Brothers store be enlarged so as to furnish the necessary steam, but this plan involved a number of difficulties and was not looked upon with favor by the owners. Furthermore, the rate suggested was not satisfactory. The choice, therefore, lay between a private plant and the purchase of steam and current supply from the Pennsylvania Railroad.

As the railroad company was the owner of the property, they were naturally anxious to give the hotel operating company as favorable a rate as possible. A thorough technical study was made of the problem by the engineers[1] for the architects and the engineers of the Pennsylvania Railroad. As a result of this study it was finally agreed that both the steam and electricity should be purchased from the Pennsylvania Railroad and that a single engine-driven 500-kw. electric generator (see headpiece) be installed in the building, this unit to be run during the winter months and use live steam, the exhaust being used for heating and for hot-water supply.

The exhaust steam from the steam engine driving the electric generator in conjunction with the exhaust steam from the steam-driven refrigerating plant, air compressors, etc., would thus be available for heating at all times when such amounts of exhaust were required. This steam-driven apparatus would therefore virtually act as a reducing valve with a consequent benefit to the hotel. The load on the generator during the winter months could be adjusted so as to supply exhaust steam in proportion to the heating requirements. On cold days the generator would be run up to its full capacity, and on warm days when the other steam-driven appa-

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[1] Messrs. Tenny and Ohmes, on the heating, ventilating and refrigerating equipment and Charles E. Knox on the electrical and elevator equipment, for the architects, McKim, Mead & White.

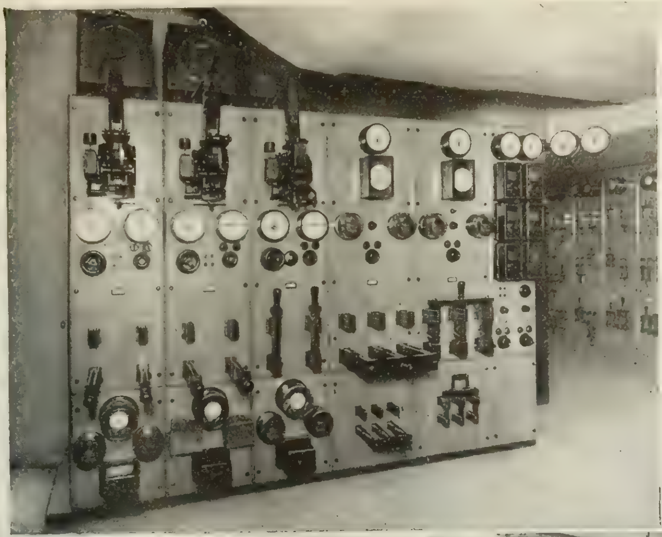
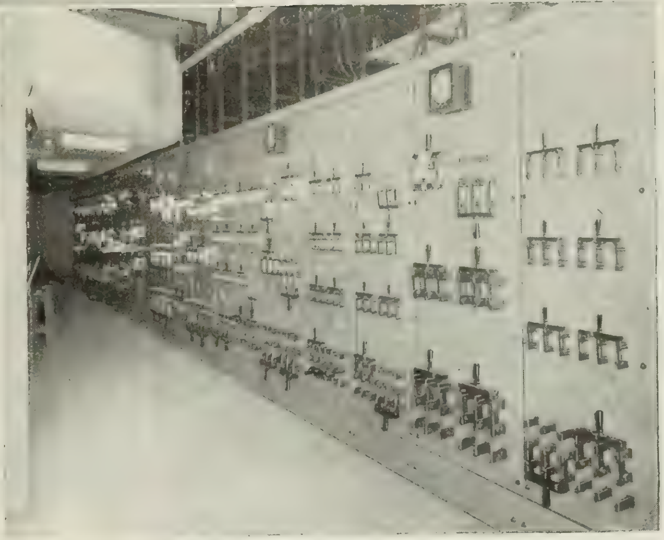


FIG. 1. SIX-PANEL SWITCHBOARD FOR THE CONTROL OF THREE 500-KW. ROTARY CONVERTERS AND THE ALTERNATING-CURRENT POWER AND LIGHTING CIRCUIT

Panels 1, 2 and 3, counting from the left, are for the control of the rotary converters—the field rheostats are shown mounted above the panels. Panels 4 and 5 are for the alternating-current light and power circuits. On panel 6 are mounted two primary ammeters, six reverse-power relays and the control for the service oil switches.

FIG. 2. TWENTY-PANEL SERVICE SWITCHBOARD

Eight panels on the left are for the control of the 240 direct-current power circuit; the next four control the 500-kw. engine-driven direct-current generator, the two 20-kw. balancer sets, and also have mounted on them the bus-tie switches; the remaining eight panels control the three-phase 250-volt power and the 125- to 250-volt single-phase lighting circuits.



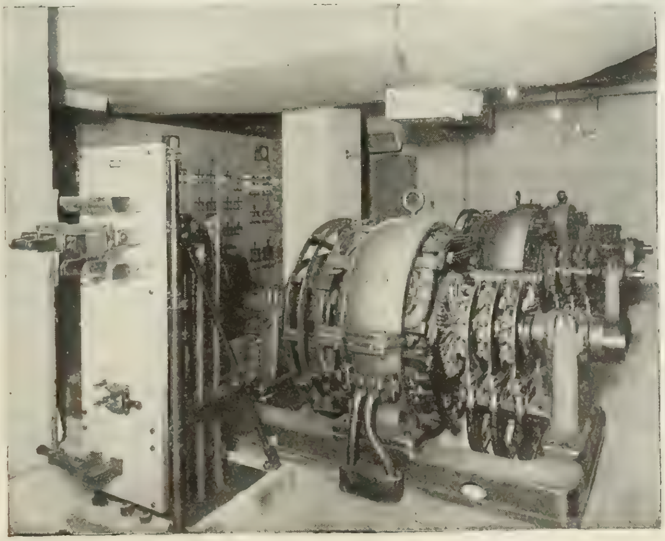


FIG. 3. THREE 500-KW., SIX-PHASE ROTARY CONVERTERS

These machines are compound-wound and are equipped with interpoles. Each converter has its own starting panel, one of which is shown in the foreground. The machines are started from the alternating-current end by connecting them, through a three-pole double-throw switch, to 50 per cent. taps on the transformers.

ratus would furnish a sufficient quantity of exhaust steam, the load on the steam driven generator would be correspondingly reduced. By this arrangement it is obvious that the cost of current production is reduced to a minimum without the necessity of installing a steam-boiler equipment and complete generating plant. The installation of such a plant would require considerable space that could be well used for other purposes, and its operation would involve the delivery of coal, the removal of ashes and a large operating force.

The electric-current supply, which is 60-cycle three-phase, 11,000-volt alternating current, is obtained from the power plant of the Pennsylvania Railroad, located in Long Island City, being transmitted to the company's service station, on 32nd St. between 7th and 8th Aves., New York City, and from there carried by two sets of No. 000 feeders through a tunnel to a substation, Figs. 4 and 5, adjoining the engine room in the sub-basement of the hotel. These feeders are connected through disconnecting switches and electrically operated oil switches to a ring bus made up of 1-in. copper tubing run exposed. From this bus the power goes to five banks of transformers. Two of these banks, each having three 133⅓-kv.-a. single-phase transformers connected delta to delta, step the 11,000-volt current down to 120 and 240 volts for lighting and miscellaneous power purposes such as the ranges in the kitchen, etc. The ranges use three-phase 240-volt power, and the lighting is supplied at 120 to 240 volts three-wire.

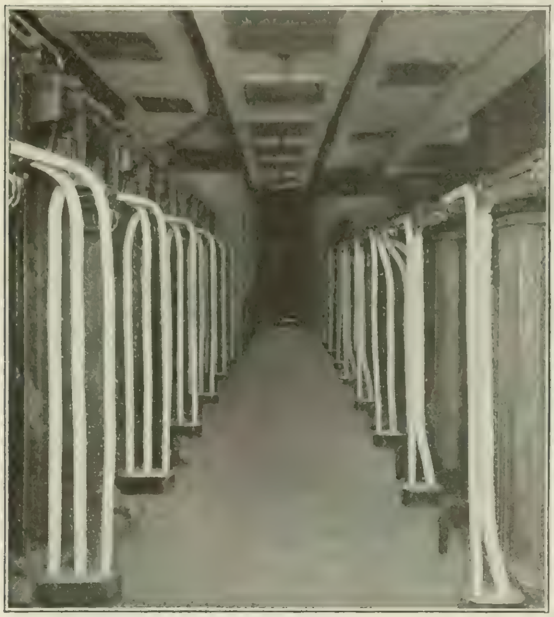


FIG. 4. INTERIOR VIEW OF SUBSTATION

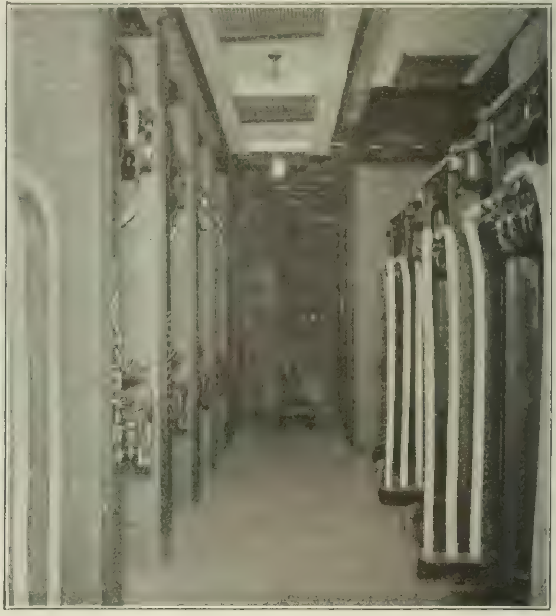


FIG. 5. VIEW OF OIL-SWITCH COMPARTMENTS

Three other banks of transformers, each consisting of three 233⅓-kv.-a. single-phase units, step the 11,000-volt power down to 187 volts to supply direct current at 240 volts through three six-phase 500-kw. rotary converters, Fig. 3. Three-wire 120- to 240-volt direct current is obtained from two 20-kw. balancer sets operated in conjunction with the rotary converters. The 240-volt direct-current power is used to drive the elevators, ventilating motors, laundry machinery, vacuum cleaners, centrifugal brine pumps, etc.

There are two switchboards in the engine room. One, a six-panel service board, Fig. 1, is equipped with the necessary electrically operated remote control for the oil switches on the high-voltage circuits. On this switchboard are also located the integrating wattmeters for measuring the current supplied to the building, overload relays, reverse-current relays, direct-current circuit-breakers for the rotaries, etc. From this board the power and lighting feeders are run to the hotel distributing board, Fig. 2, consisting of 20 panels, which serves to control the main feeders distributing current to the various parts of the building. In addition to the two switchboards just described, there is one in the laundry for all motor-operated laundry machines, one on the second (service) floor, a six-panel board for all bedroom-floor lights and one on the roof floor to supply power for ventilating motors, elevators and lights on this floor and above.

There are six subfeeders from the main switchboard to the switchboard on the roof floor and eleven subfeeders to the switchboard on the second (service) floor. There are also 112 power risers having a total of 2456 hp. connected load (not including the laundry). Of these 27 are for elevators, having 1108-hp.; one hundred and eighteen lighting risers feed 240 panel boards supplying an aggregate of 3415 circuits, having a total capacity of 2,253,900 watts. There were used in the installation of the various circuits over 600,000 ft. of conduit of all sizes from ½-in. to 4-in., and about 2,000,000 ft. of wire of all sizes from No. 14 duplex to 2,000,000 circ.mil cable.

As the 27 elevator machines are all located in penthouses on the roof, the current supply for these motors is carried by feeders from the main switchboard in the subbasement to the power switchboard on the roof floor. From this power switchboard the feeders are extended to separate distributing boards, one in the passenger-elevator pent house and a second in the service-elevator penthouse. A tie-line switch is provided on the switchboard at the roof floor, so arranged that the feeders supplying the passenger and service elevators may be tied together electrically and, by taking advantage of the diversity factory resulting from the operation of the two banks of elevators, gain the benefit of the combined carrying capacity of the two sets of feeders. Additional feeders are run from the main switchboard in the sub-basement to the switchboard on the roof floor for supplying ventilating and other motors located on the roof floor. Lighting feeders run from the main switchboard in the sub-basement to the roof switchboard for supplying lighting on the roof floors.

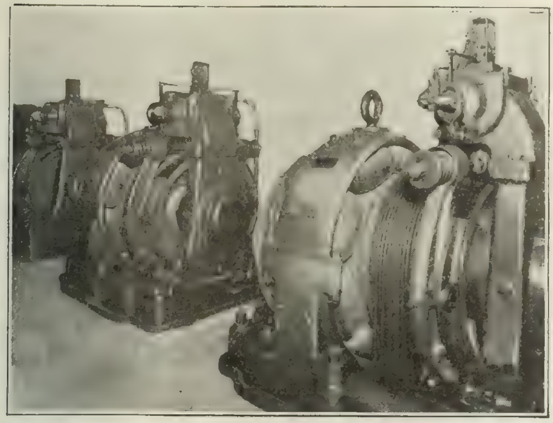


FIG. 6. THREE OF THE TWELVE PASSENGER, DIRECT-TRACTION ELEVATOR MACHINES

In the design of the feeder system the size and arrangement of the feeders were determined with a view of reducing the amount of copper required to a minimum and at the same time avoiding the possibility of having such variation in voltage as would materially affect the candlepower of the lamps.

The consulting engineer had a large amount of data based on the maximum-demand factor on the feeder systems of various hotels, and the loss was determined on the connected loads using the demand factor found to exist in hotels of this class and the allowable loss then determined. As the variation in candlepower is much more rapid than the variation in voltage, it is obvious that if too great a loss were permitted in the feeders, the resultant reduction in light produced in the lamps might cause complaints from guests and compel an increase in the size of the lamp. On the other hand, good engineering required that no more copper be used than necessary to obtain proper results. Economy was also secured on the branch circuit wiring by putting as many as ten or twelve outlets on a circuit. This is permissible in a hotel for the reason that additional outlets are seldom required in the bedroom portion of hotels, and in this respect it is different from conditions in other types of buildings.

The main feature of interest in the way of illumination is the lighting of the lobby. The ceiling is of glass arranged in an attractive design, supported on steel framework. Special glass in two colors is used, and in the space above the glass ceiling are placed a number of lamps with efficient reflectors, arranged for control in three groups. The lighting effect is very attractive and is obtained with an unusually small expenditure of energy for this type of lighting. Standard fixtures are also located on the floor, which are used in connection with the lighting above the glass ceiling. The service portions of the house are generally lighted by lamps with porcelain enamel steel reflectors, close to the ceiling, the object being to obtain fixtures requiring a minimum amount of cleaning. Metal reflectors are used to accomplish that purpose and also to avoid breakage.

In the design of the signaling systems the object sought was to keep the installation as simple as possible, reducing the initial expenditure to a minimum and at the same time to give the guest every convenience which the exacting demands of a modern hotel require. As an instance of the simplification of design, no push-button calls are provided from the bedrooms, the telephone being used entirely for transmitting the guests' desires and requirements.

On each bedroom floor a floor clerk occupies a desk opposite the main elevators. From this floor clerk's office pneumatic tubes extend to the tube station at the back of the main office, and a telautograph connects with the room clerk, valet, porter, laundry, etc.

The principal means of transmitting information are the telephone, telautograph and pneumatic tubes. The main telephone switchboard consists of 23 positions, including 9 incoming, 2 official and 12 house positions. The incoming positions are used for receiving messages from outside of the hotel; that is, incoming calls. The official positions are used for connections for the administration officers of the hotel and the house positions are used for the guest's service, including the outgoing messages. The telautograph system consists of 60 stations and is used for transmitting messages left by visitors and for breakfast orders, etc., and therefore constitutes an important factor in the hotel.

The watchman's detector system is of the portable type, with the addition that on each floor there is provided a separate watchman's station connecting with an outside supervised service. The fire-alarm system is also of the interior type, connecting with the engine room and with an additional signal station on each floor and directly through the National District Telegraph Co. with fire headquarters.

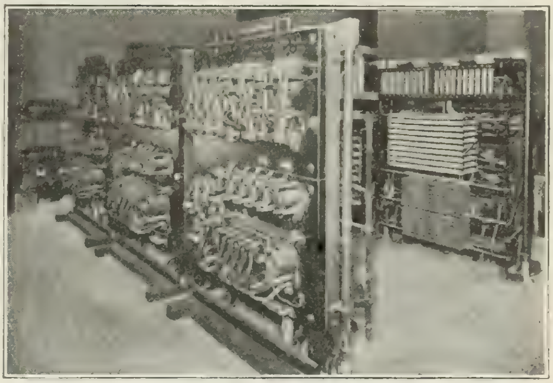


FIG. 7. ELEVATOR-MACHINE CONTROL PANELS

There is one group of main passenger elevators consisting of two rows of six elevators each, opening on the passenger-elevator corridor. These elevators run from the basement to the roof floor, and by placing them in one group it was deemed that better service to the guests would be provided and less confusion would occur in locating the elevators.

Two elevators are installed at the southwest corner of the building, which serve to carry passengers from the tunnel connecting with the Pennsylvania Railroad station and the subway, to the main floor. At 33rd St. side of the building near the ballroom entrance two elevators are provided for carrying passengers from the main floor to the ballroom floor, about twenty-five feet above the ground floor.

Eight elevators in one bank are provided for the service requirements of the hotel. These elevators extend from the sub-basement to the roof and are arranged to be operated in three separate groups so far as signaling is concerned, thereby permitting a certain amount ot flexibility in assigning the elevators to different purposes. For example, one pair may be used for waiters exclusively, another pair for baggage, laundry, etc. The passenger elevators are arranged so that one side of (six) elevators may be run local and the other side may be run express. All the passenger and service elevators with the exception of one large service elevator are of the one-to-one gearless-traction type as shown in Fig. 6, running at 600 ft. per min. On the left, Fig. 7, are shown three of the controller panels for the passenger elevators; the arrangement of the resistances and wiring on one controller panel is shown on the right of the figure. The large service elevator, which is approximately nine feet wide by seven feet deep, is of the worm-gear traction type running at 450 ft. per minute.

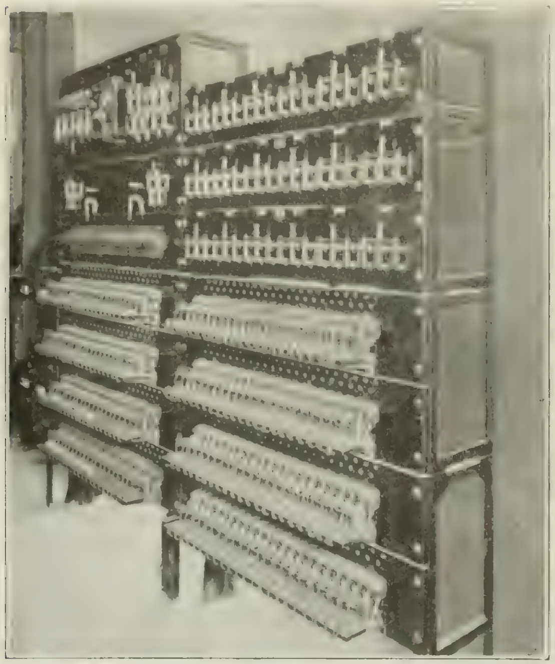


FIG. 8. PASSENGER-ELEVATOR SIGNAL BOARD

In the rear of the building there are three additional elevators which serve to carry supplies from the driveway to the lower floors and also to provide service between the sub-basement and the banquet-room kitchen which is located on the first mezzanine floor.

The signal system for the passenger elevators consists of up and down flash-light annunciators in the car with push-buttons and up and down signal lanterns located at the various landings. Fig. 8 shows the signal panel board for the twelve passenger elevators. Dial indicators are placed on the ground floor as well as telltale annunciators for furnishing to the elevator starter the necessary information as to the location of cars and the car signals.

Door closers of the pneumatic and spring-actuated type are provided on all passenger and service elevators. On all passenger elevators a simple safety device is used to prevent the car moving until both the hatchway door and the car gate are closed.

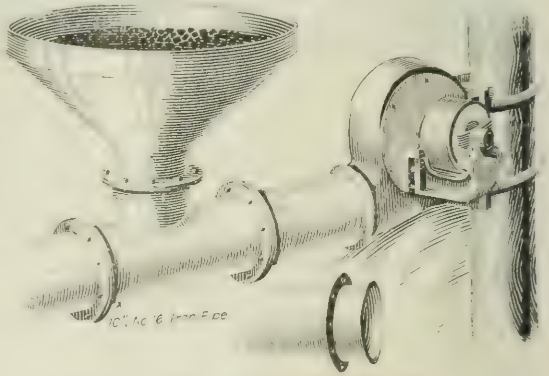
A bank of six dumbwaiters is provided for furnishing service between the kitchen and the various floor pantries, one being located on each of the bedroom floors. These dumbwaiters are operated on the single-point control plan; that is, an operator in the basement kitchen controls the movement of these cars and dispatches the dumbwaiters to the various floors in accordance with demands or signals received from the floors. These signals are indicated on the annunciator in the basement kitchen. The dumbwaiters run at a speed of 500 ft. per min. and are capable of carrying a load of 100 pounds.

Storing Coal With a Fan

By H. H. Finch

The following method of handling coal for storage at our plant may be of interest to readers of *Power*. The illustration tells the story. This machine is made from an old blower, and it will handle coal faster than four men can feed the hopper. We had for several years been storing coal on a lot about 200 ft. square and a number of men were generally employed in wheeling it back. This was slow and expensive, and in order to eliminate useless work and expense I had some 10-in. diameter pipe made from No. 16 iron joined together end to end, each end being flanged and fitted with a collar for the purpose of securing the pipe lengths together so that they would not work loose. The tee to which the hopper is secured is made of cast iron.

In order to keep the coal on the lot a back-stop was put up, but this did not stop the dust, so a hole was made about two feet from the discharge end of the pipe and a hose nozzle so inserted as to spray water against the air blast, which broke up the water into a fine mist and mixed it with the coal.



MOTOR-DRIVEN BLOWER FOR STORING COAL

The pipe was about 70 ft. long in 10-ft. lengths. The blower is driven by a 25-hp. motor, and the coal is stacked from ten to twelve feet deep. It can be stored at a very low cost with this machine.

Operation at Holtwood

Lubrication of Submerged Pins in Governor Operating Mechanism

By
Charles H. Bromley

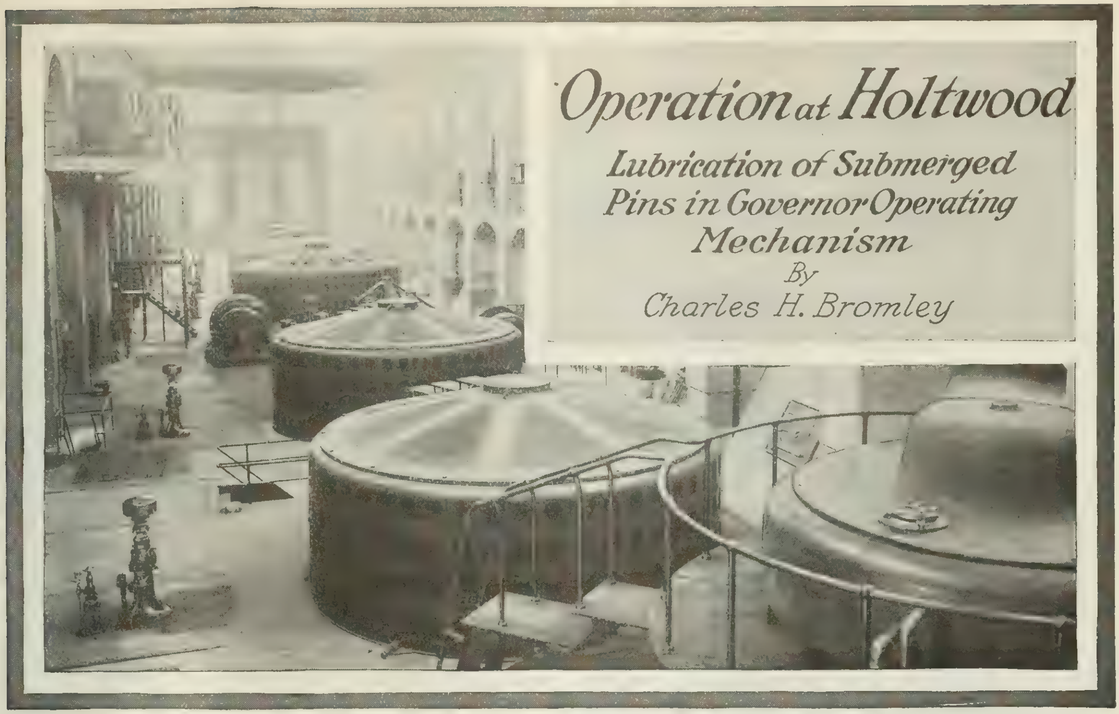


FIG. 1. EIGHT GENERATORS RATED AT TOTAL OF 83,500 KW. AT HOLTWOOD ON THE SUSQUEHANNA

Wear and corrosion troubles in the link pins, vane pins, reach-rod and wristpins of the double-runner units have been overcome by the use of monel metal for these pins. Micarta bushings are now being tried, and experience so far indicates good results. The large submerged pins, which originally had no lubrication other than that given during periodic overhauling of the turbines, are now lubricated from the turbine-room floor by means of a grease gun from which a separate pipe runs to each pin. These improvements have increased the interval between general overhauling of the units at least threefold.

Before the wheel of each turbine there are a number of wicket gates for regulating the flow of water to the wheel. These gates are moved by operating cylinders and their connections, the actuating water pressure being 275 lb. per sq.in. A partial view of the external operating mechanism as

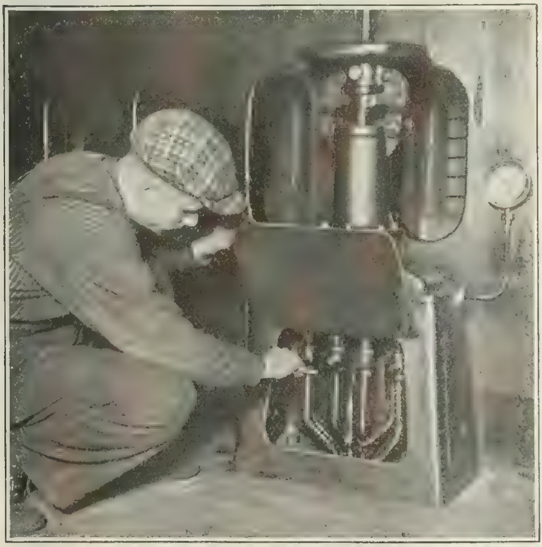


FIG. 2. FLOORMAN USING THE GREASE GUN ON THE TURBINE-ROOM FLOOR FOR LUBRICATING SUBMERGED PINS

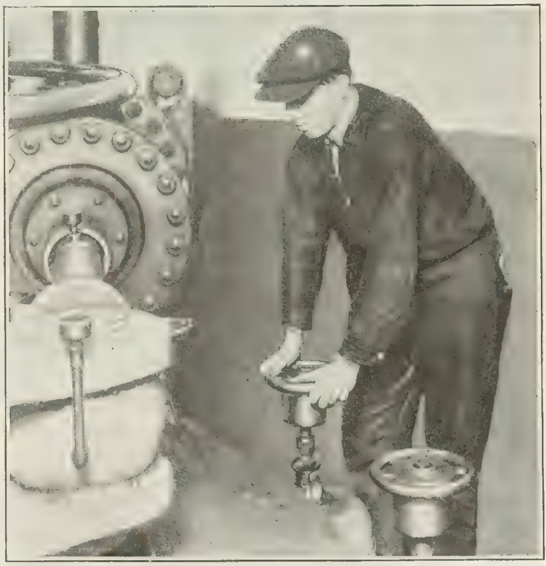


FIG. 3. PUMPMAN GIVING PART TURN TO GREASE GUN SUPPLYING GUIDE-VANE LUBRICATION

applied to the new, or No. 8, unit is shown in Figs. 3 and 7. In this machine the pins for the wheel gates are not under water and are lubricated by the individual grease cups shown in Fig. 3.

On the double-runner units Nos. 1 to 7, the link pins, vane pins, reach-rod and wristpins are all under water. The original design did not provide for lubrication of these pins while in service; they could be lubricated only when a unit was taken out of service for major overhauling, the wheel pit pumped out and a working platform and rigging put up inside of the pit.

The friction due to gritty deposits from the river water not only wore the pins, but imposed a heavy load upon the operating mechanism for moving the gates and their connections. Besides, the corrosion of the pins was considerable and when corroded the coefficient of friction was affected accordingly and thus in turn the strains on the operating mechanism further increased. The wear is shown in Fig. 8, where some of the worn pins of the older type are contrasted with new pins. Such wear, if permitted to increase excessively, will produce considerable slack and lost motion, and inability to produce full gate opening. Vanes, with operating piston in completely closed position, will permit excessive leakage; governor action of the turbine and equal distribution of stresses in mechanism will be affected.

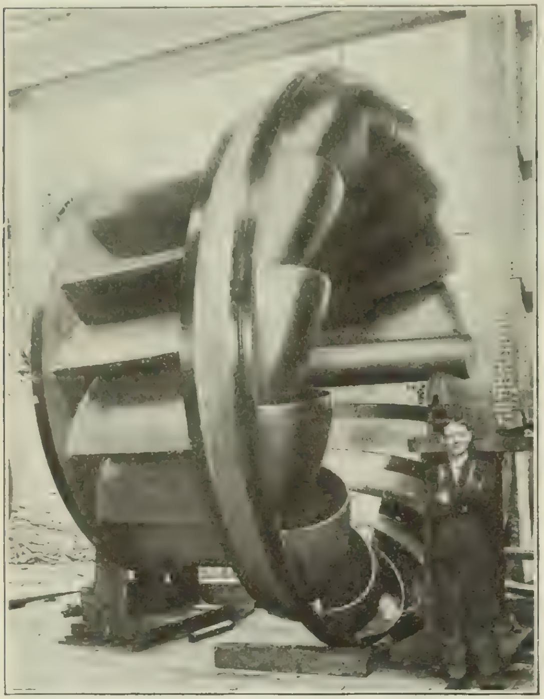


FIG. 4. RUNNER OF THE 17,000-HP. TURBINES

To overcome the trouble of excessive wear and corrosion, pins were first made to operate in bushings of different metals, such as brass, bronze, graphitized metal and other alloys; zinc-impregnated pins were tried, but the expected electrolytic action ate away the zinc too quickly. Experience showed that lubrication was necessary on the larger pins and a grease gun was designed, by means of which properly graded lubricant can be forced directly to these pins from the turbine floor. Looking at Fig. 2 a number of ½-in. pipes, each leading to one pin only, can be seen. Each pipe has a cock at the point where it leaves the chamber of the grease gun. One cock is opened at a time,

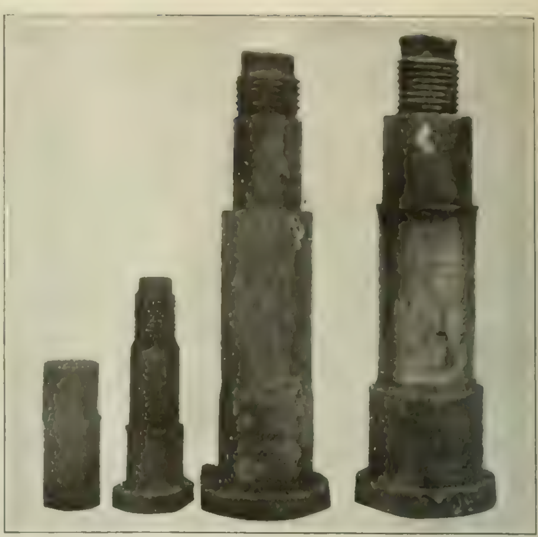


FIG. 5. CORRODED STEEL PINS CONTRASTED WITH MONEL PIN LONG IN SERVICE, SLIGHTLY WORN BUT NOT CORRODED

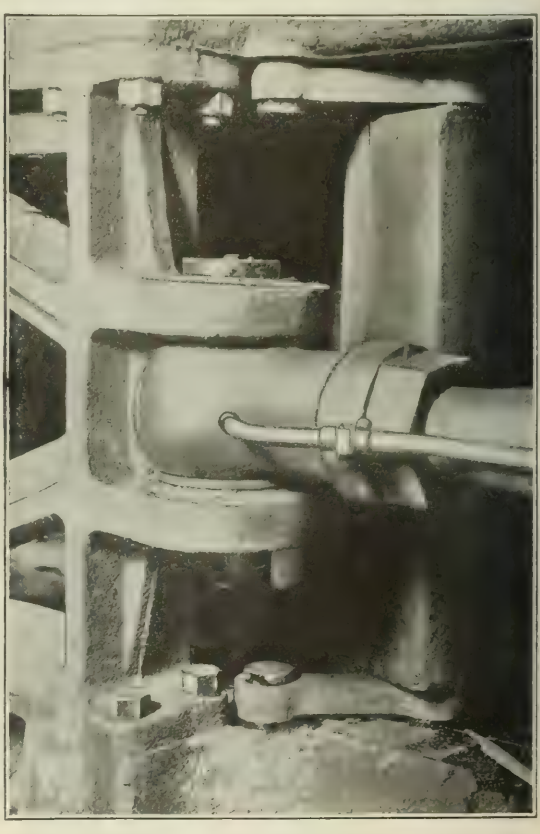
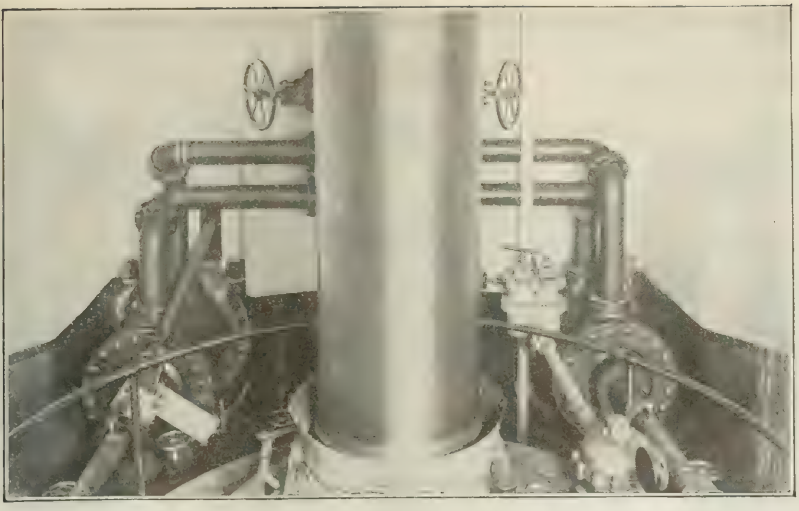


FIG. 6. INDIVIDUAL GREASE PIPE TO SUBMERGED REACH-ROD PIN



For the smaller-sized submerged pins monel metal has been found, so far, most suitable to resist wear and corrosion under Holtwood conditions. Micarta bushings have also been experimented with recently, on pins operating under light specific pressure, with apparently good results, but have not yet been sufficiently long in service to permit of any definite comparisons. While, formerly, main units required thorough overhauling approximately every two years, the results so far obtained from the foregoing improvements promise to increase the interval between overhaulings at least threefold.

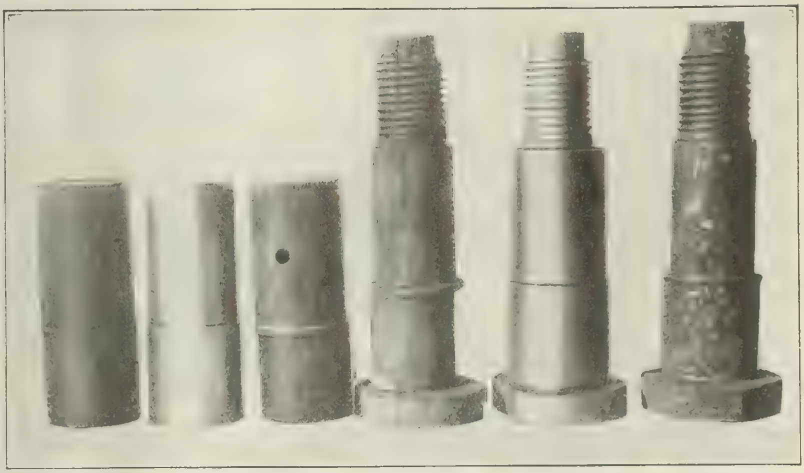
FIG. 7 (ABOVE). ARRANGEMENT OF TWIN OPERATING CYLINDERS OF SINGLE-RUNNER UNIT

Note on cylinder to the left the attachment for indicator to record lost motion and operating pressures.

FIG. 8 (AT THE RIGHT). SHOWING WEAR OF THE SUBMERGED LINK PINS AND VANE PINS

Old steel pins contrasted with new monel pins. Note corrosion of the old pins.

FIG. 9 (BELOW). VIEW OF THE "LAKE" AND FOREBAY FROM ATOP THE 360-FOOT HILL AT HOLTWOOD



and the handwheel actuating the piston in the gun cylinder is given a certain fraction of a turn within stated intervals.

After several years of service these grease guns have resulted in a very appreciable decrease in the maintenance of these parts of the turbine. The former necessity of increasing the governor pressure has passed, and better regulation of turbines and a number of other incidental advantages were secured.

During the high-flow months the regular maintenance force keeps track of the conditions of the unit as to lost motion, leakage, operating resistance in mechanism, etc. A standard Crosby steam indicator is used for that purpose, and the results are plotted on an inspection chart that shows at a glance how lost motion, operating pressure, etc., are affected from year to year. This chart serves then as a guide to decide which unit should be selected for the overhauling work.

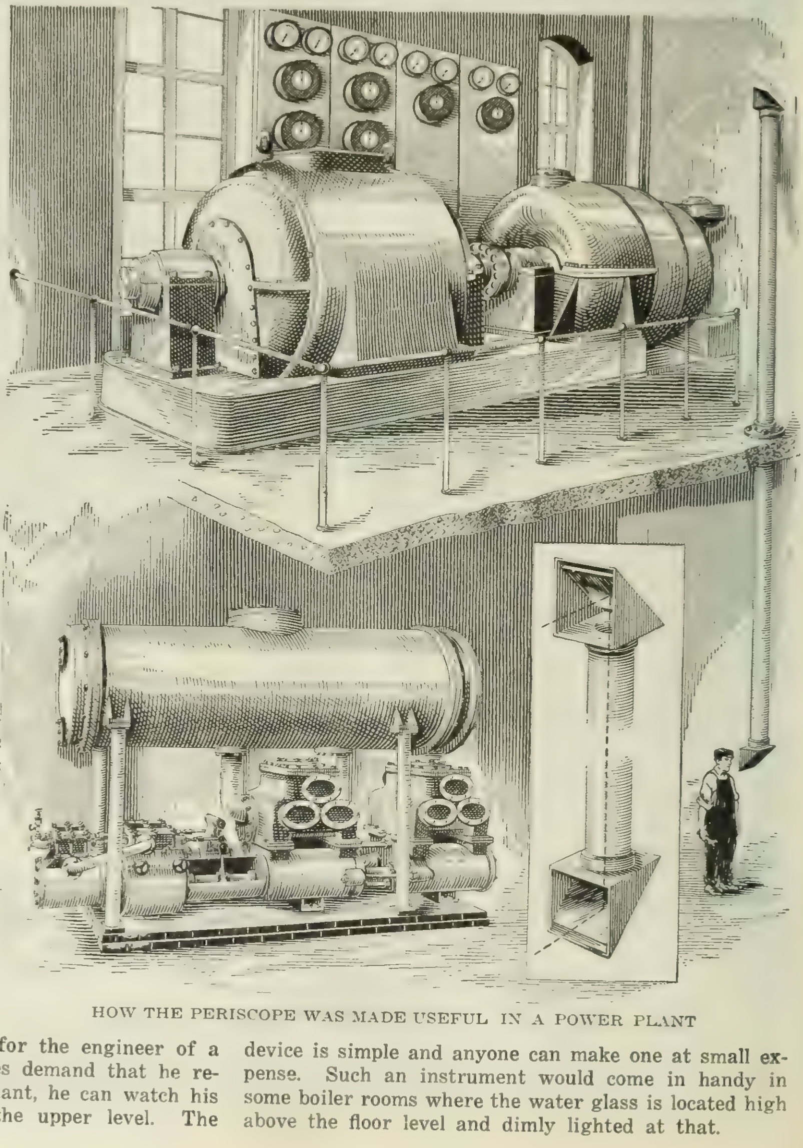
Periscope in War and Peace

by J. M. Purcell

THE following idea illustrates how one engineer succeeded in making a convenient instrument for himself, using a device that had made the U-boat the terror of the sea—the periscope. The periscope enabled the U-boat to remain below the surface unseen, and at the same time observe its approaching prey.

The use of a home-made periscope enabled an engineer to do his necessary repairs in a basement and to observe at intervals his instrument board, on the mezzanine, about fifteen feet above.

In this particular case the instrument board and turbine were on the mezzanine floor, and the condenser and various other machinery on the main floor. For his conveni-main floor. For his convenience, the engineer took a leaf constructed a simple periscope as illustrated. It was made out of some old 3-in. fiber conduit, two mirrors and a housing to contain the mirrors. The same principle can be used in more difficult situations than the one described, by using the necessary number of mirrors. To make the device successful, the object to be observed should be intensely lighted. The mirrors should be at an angle of 45 deg. with the center line of the conduit.



HOW THE PERISCOPE WAS MADE USEFUL IN A POWER PLANT

This device is a convenience for the engineer of a small plant, because if his duties demand that he remain in the lower part of the plant, he can watch his instruments without going to the upper level. The device is simple and anyone can make one at small expense. Such an instrument would come in handy in some boiler rooms where the water glass is located high above the floor level and dimly lighted at that.

Spike McNally's Nonexploding Flywheel

By E. E. CLOCK

SPIKE McNALLY, as he was known to his friends, was chief engineer, master mechanic, blacksmith, millwright and electrician for the company and, if tradition runs true, he never got stuck. It was while I was in the little four-by-nine office of the superintendent of the Victory Mining Co., in southeastern Kansas, that I made his acquaintance.

Spike came into the little office and, as Mr. Sutton, the superintendent, turned toward him, he said, or rather exploded, "Say! where in the name of all that's holy did you pick up that bunch of bums and hobos that you sent me for firemen?" And as the roof of the little shack rose up and settled again, he took breath for a fresh blast and continued: "Those fellows couldn't fire a haystack soaked with gasoline," and as the window panes cracked, one after the other, he went on: "There ain't any one of them knows as much about firing as Bill Brine knows about steering the Ship of State. We've got to get some different men down there or that boiler house will be making ice and the North Pole will be a summer resort alongside of this place before morning." With that he went out, and as he pulled the door shut, the front of the little office bent outward visibly.

The superintendent turned to me and said: "He ain't got no use for a wireless telegraph. If he wanted to commune with President Wilson in France all he'd have to do would be to stick his head out of the window and let loose with that voice of his'n; they'd hear him. He'd crack the glass in the Royal Palace worse than Big Bertha. If he comes in here again and opens that bazoo of his'n, I'll take him by his breath and pull his lungs out."

"Well," I said, "you'd better get a bucket to put them in for here he comes now." And as I spoke Spike stuck his head in the door and yelled: "It's a damn good thing those bums can't make steam. They'd blow this shebang to kingdom come. One minute the water is halfway up the smokestack and the next it's way down in the sewer," and with that he withdrew his head and sprang the door casing some more.

The superintendent turned to me and said: "He don't like them firemen."

"I was just beginning to surmise something of that sort," I said. "Are they as bad as he paints them?"

"Well they ain't what you would call experts—most hobos ain't—but you got to discount about half of what Spike says to get things right. But let me tell you one thing—they will be experts if they don't hop the rattlers before he gets them trained, and it won't take him long either. He'll put them through a course of sprouts that'll graduate them to Spike's way of doing things in jig time, and if they have a rugged constitution and last long enough to graduate, some other cuss will win them away with more pay like enough, and if you are around here about that time you will think Spike was only whispering today."

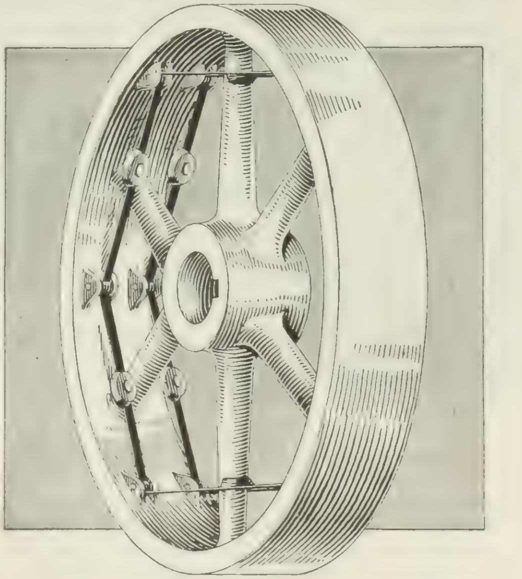
"Is Spike a good mechanic?" I asked.

"None better in the county," answered the superintendent. "Why, any time they get stuck anywhere around here, they send a buckboard after Spike and he fixes them up every time; and it don't make any difference what they stack him up against, he never gets stuck. You see this electric light here? Well, he made the dynamo that makes that light. We had kerosene lamps around here, and one day when the president of the company was down from New York, Spike asked him for a dynamo. 'Can't afford it,' said the president. 'Why, it would cost a thousand dollars.'

"'Great balls of fire! I can make one that won't cost a hundred,' retorted Spike.

"'Why don't you?' asked the president, and then he laughed up his sleeve, which was a habit he had when in the presence of an extra-good joke of his own hatching. But the next time he came down he had to laugh up the other sleeve, for Spike had the thing finished and running and we had an extra illumination for the occasion. Spike was lit up himself that night slightly, and after the president had been out and seen the dynamo, he pulled his checkbook out and says to Spike: 'Well, what size check will it take to cover you for the material you bought?'

"Spike said, and you could a'heard him to Texas: 'Keep your money, Mr. President. Maybe I won't stay here always and when I go she goes with me.' You see Spike went over ten miles to a place where they used to haul ore on a trolley line, and there was a lot of trolley wire out in the weather and he wired up this place with it, made wooden cleats and everything, and it is just the dandiest thing you ever saw. I wouldn't have covered wires after seeing this outfit. Why, when anyone wants a light any place, all he has to do is to have a lamp and socket and a pair of short wires to hook across the leads and up she lights."



SPIKE McNALLY'S NONEXPLODING FLYWHEEL

"What's the voltage?" I asked.

"Fifty," said the superintendent, "and that's plenty."

"What does he do for fuses and such things?" I asked.

"Fuses?" said the superintendent. "Why, they ain't one on the place."

"How about short-circuits and overloads?"

"Why, the belt comes off the dynamo or the little engine that drives it gets stalled."

"I guess he must be quite a genius," I said.

"You said a mouthful," rejoined the superintendent. "You don't have no idea. Sometimes I think he is so full of it that he is kind of looney. Why! we had a lot of ore-dressing machines here that couldn't keep up to the big crackers and kept getting swamped with ore all the time, and we speeded them up and speeded them up till we got them where they could handle all that came down the sluiceways and then we were up against another trouble—the darn flywheels kept busting. One day one of them winged a greaser and came near killing a good mule. We couldn't slow them up without going back to our first trouble, and so we sent for a man to come out from the St. Louis shop, where they were made, and when he had checked up the speed and found it 'bout a mile and a half a minute on the rim and had sized Spike up for a hick, he began to spit figgers and rules and preached a nice little sermon on centrifugal force, etc., and said no one could make a flywheel that would stand that speed; and if he had been the lord high chief of the soupreem court, he couldn't have laid down the law any better on margins of safety, coefficients, tangiental efforts, etc. Well, he preached that stuff to Spike till it kind of got on his nerves, and Spike said:

" 'So you can't do anything to stop them wheels from busting, hey? Can't fool this here centrifugal force so as to make it reverse itself and hold those wheels together? Couldn't vaccinate them wheels with centrifugal force so as to cure the original disease or leastwise use some of this centrifugal force to keep the wheels from busting?'

"The St. Louis man looked at me and then at Spike and estimated the jumping distance through the window in case Spike got violent, and passed his hand over his eyes kinda like a man in a dream and edged toward the door, and Spike said: 'Well, I can, and I'll do it, too.'

"Saint Louey got one hand on the door knob and he said: 'When you do, I'll go up and drive a nail in the moon to keep it from falling.'

"Spike said: 'If I make up a sketch of such a wheel and if the sketch shows plainly that it will do just as I have said, will you make us up one for each of those machines?'

" 'Yes, and nickel-plate them besides,' said the St. Louis man, quickly.

" 'Mr. Sutton, get that in writing while I make the sketch,' said Spike.

"The Saint Louey fellow readily wrote his own scenario and signed it, and in about ten minutes in came Spike with the sketch and handed it to him with the remark:

" 'There is your vaccinated flywheel. Make us up one for each machine and if they don't collapse from the high speed we're running, I ain't afraid of them busting.'

"The man sat and looked at that sketch like he had took dope, and finally he woke up and he said: 'I guess he's got me, by cracky! It'll do it, sure as guns! Wait till the office sees this sketch and the contract I've signed'!

"Well, they were game and they made them up, and they have been running five years and you couldn't bust them with any kind of speed.

"They only required the ordinary pattern to have four lugs cast in the middle of each arch, two on each side, about two and a half inches apart, through which short pins were put with a piece of thin pipe for a roller; then an endless band of strong but thin steel was strung under these rollers one on each side of the spokes, you understand, and small cast-iron weights were riveted in the bands as shown, one of them being used as a splice for the band. As the speed increases, the weights tend to go out away from the center and exert a strong inward pull on the pulley arches right where it is needed. It was so simple and worked so well that those Saint Louey fellers came up here and took a lot of pictures of them; and after they had all the pictures they wanted, they risked the camera on Spike, too. I listened for the sound of falling glass, but nothing happened, and so I say Spike has got some funny old gray matter in that head of his."

Improved Green Chain-Grate Stoker

A general view of the improved Green chain grate would have much the same appearance as the stoker the Green Engineering Co., of East Chicago, Ind., has been making for over 20 years, but beginning with the driving mechanism there have been radical changes. Although the steel spur-gear drive has been retained, the gear frame and cover have been combined as shown in Fig. 1, eliminating joints and strengthening the construction. The side girders, of heavy design and of channel-shaped section for strength and for freedom of air supply, are located eight inches below the fire line.

Another improvement is the use of chain skids to support the upper and lower leads of chain in place of the former pipe-roll construction. The skids are constructed of rails with hardened heads to resist wear. The ends are curved to receive the chain from the sprockets at the front. As shown in Fig. 2, the skids are supported by transverse I-beams connected to the side girders. The grate is held level and there is no sag between rollers to open up the spaces between the links. It is claimd that the siftings have been reduced to less than one-third of the amount passing through when rolls were used.

The gate-operating mechanism now employed consists of a steel cut-worm and worm gear turning a pipe resting in trunnions and to which the gate is attached by means of chains, as shown in Fig. 3.

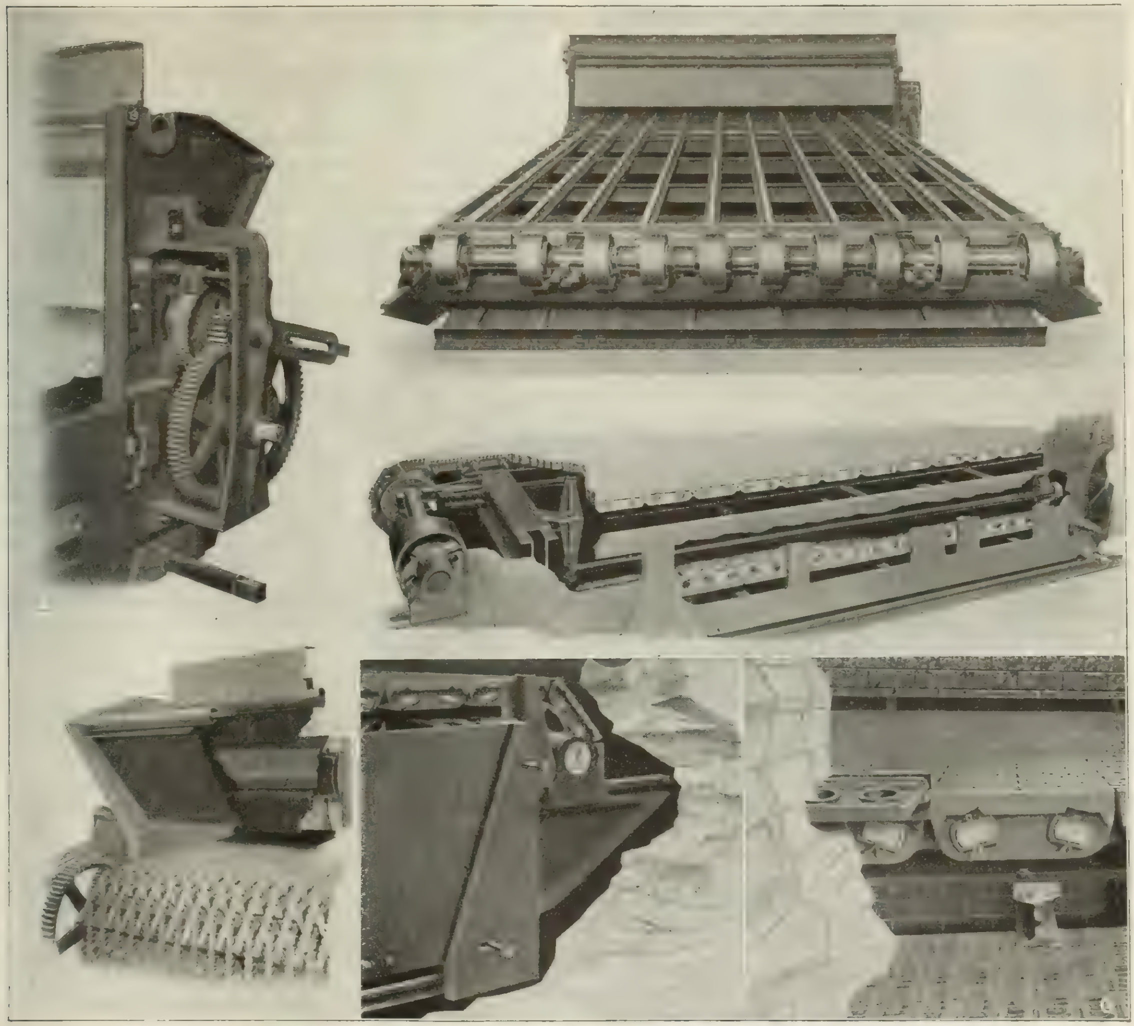
At the fire line the side frames of the stoker are protected by cooling plates consisting of small castings with air circulation between them and the side frames. The cooling plates extend around both sides of the frame and prevent overheating.

On the rear shaft, as shown in Fig. 2, plain drums are used instead of sprockets. The drums afford ample bearing surface and also tend to prevent climbing of the chain at the rear. On stokers 7 ft. 6 in. wide and over, the intermediate shaft of the driving mechanism is carried across the stoker and there is a pinion and drive gear on both sides of the stoker to eliminate torsion in the sprocket shaft or lagging of the stoker chain.

An ingenious improvement is the adoption of a tension take-up at the front. Fig. 4 shows the idea. All adjustment is made at the front from the outside of the boiler setting. The operation consists of adjusting a brass nut at the end of a tension rod at either side of the stoker. At the rear the mechanism consists of a rocker arm with a fulcrum at the center secured to the rear girder. At one end is attached the tension rod running to the front of the stoker and at the other end a rod communicating with the rear shaft at the quarter point. At the other side of the stoker this mechanism is duplicated. Tightening up on the tension-rod nuts pushes back the rear shaft, which is mounted on rails and is free to slide. This operation takes up the slack in the chain.

Air exclusion at the rear of the stoker and along the sides is thorough. Between the chains and behind the rear cross-girder is a heavy damper with swinging cast-iron sections at the top and bottom. This damper makes contact with the upper and lower leads of chain. Between the side girders and the brickwork the air seal is effected by dampers, as shown in Fig. 5. This damper is formed by a flange upon the side girder shouldering against a companion flange bolted to the furnace side wall. Adjustable ledge plates and flanges, Fig. 6, make a seal between the stoker chain and the furnace brickwork. The plates and flanges are in 3-ft. sections and can be adjusted to make close contact with the chain. This type of air seal permits the raising and lowering of the rear of the stoker to produce varying heights of ash discharge.

Pressure water-backs complete the seal between the fuel bed and the bridge-wall. They are connected into the boiler circulation, are circular in section so that they may be turbined and are free to expand and contract. Below the lower chain, air from the front is baffled off by means of a transverse damper attached to the lower sides of the stoker. With this system of seals practically all air entering the furnace must pass through the fuel bed.



FIGS. 1 TO 6. ILLUSTRATING SOME OF THE DETAILS OF THE IMPROVED GREEN STOKER

Fig. 1—Stoker-driving mechanism. Fig. 2—Chain skids and rear drums replacing sprockets. Fig. 3—Coal side of fuel gate. Fig. 4—Front tension take-up. Fig. 5—Side girder damper. Fig. 6—Adjustable ledge plates.

Economies in a Mine Power Plant

By J. A. Carruthers*

In the power plant in question a reduction of thirteen to fifteen tons of coal per day was made in the fuel used as a result of several changes in the equipment. This coal, in contrast to the usual coal-mine power-plant fuel, was a high-grade steam coal and could in no sense be classed as a drug on the market.

Briefly, the power plant consisted of eleven return-tubular boilers with a manufacturer's rating of 150 hp. each, and 104 hp. government rating. Taking the former rating and allowing one boiler off for washing, the total was 1500 hp. The power house contained three air compressors and two generator engines, all of the compound-condensing type. The generator engines were operated alternately, twenty-four hours. The total indicated horsepower of the four units under regular running conditions was 1425 to 1475. In addition there were a couple of service pumps and four jet condensers to operate. Outside the power plant were several engines used for fans, hoists, shops, coal-crusher, car-loaders, etc., which totaled about 300 hp. This added to the power-house load total made an average of 1750 hp. The air compressor load would often increase 30 to 50 per cent. for days at a time, owing to the demand for air in the mines.

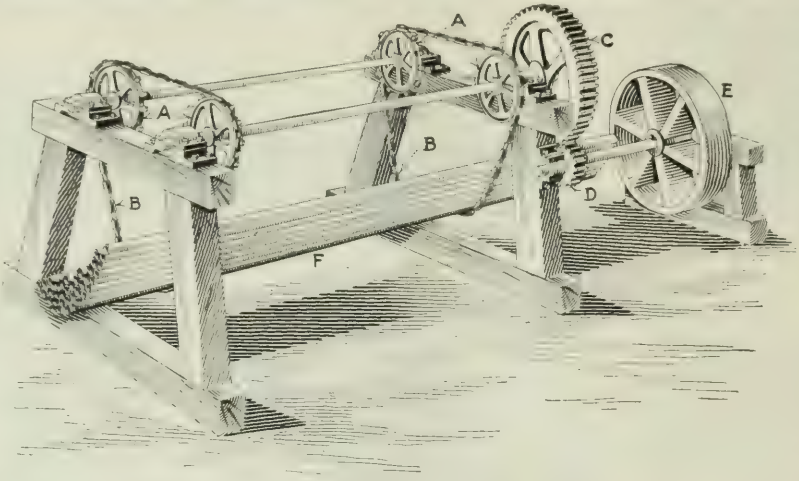


FIG. 1 RIG FOR REMOVING SCALE FROM BOILER TUBES

Several of the boilers leaked badly at the rear end of the tubes, and examination proved that they had been rolled to a finish. A hard scale inside the tubes extending about a foot from the head was one effect of the leakage. As these same boilers were badly scaled inside on the back head and a portion of the tubes, four of the worst ones were cut out and retubed.

With tubes at war prices new ones were put in the first boiler only. The old tubes in the meantime were cleaned with the home-made rig shown in Fig. 1 and then welded up for use in the next boiler cut out. In replacing them the new ends were put to the back end of the boiler. New tubes at that time cost about $11 each, and there were 70 to each boiler. The cost of welding up the old ones averaged about $3.20 each.

These boilers, in common with most others of their type, had the grates set a bare two feet below the boiler shells. This gave very poor furnace conditions for the coal used. To make these conditions worse, the bridge-wall had been built to conform to the curvature of the boiler shell, and at a distance of from ten to twelve inches from it. The result was that the gases were deflected against the relatively cool boiler surface before they had much chance to burn.

As a remedy for this poor furnace design, the grates were lowered considerably, as shown in Fig. 2, and the bridge-walls were rebuilt flat on the top at a distance of about 16 in. from the shell. The added furnace volume and free passageway afforded the burning gases to the back combustion chamber combined to give a much higher furnace efficiency. The increase in temperature was proved by the shorter life of the firebrick; also, the less amount of coal fired was soon noticed.

In lowering the grates, it was decided to replace the cast-iron fire-door arches and deadplates with firebrick. These castings cost between $70 and $80 to renew about every five or six months. This price refers to the cost of renewal of the castings per fire-door.

The boilers had individual steel stacks with no dampers fitted, so that the only draft regulation was by means of the ashpit doors. These were badly warped, and most of them would not close at all. Besides, this regulation was of no use when cleaning fires. As hand firing was used, at cleaning time the cold air rushed through the setting with full draft intensity, causing a considerable drop in temperature. To remedy this, as each boiler was cut out for washing, a damper was fitted to the stack and the adjusting rope dropped within convenient reach of the firemen. After these were installed, the firemen were instructed to nearly close them when cleaning fires. It also gave some control over the fires if one of the large engines happened to shut down unexpectedly, and less coal went through the pop valves in the form of steam. The cost of making and installing the dampers was small.

Before finishing up in the boiler house, about $300 worth of a good quality of pipe covering was put on the 16-in. steam header above the boilers in place of the original covering, which was of poor quality. The covering on top of the boilers was also overhauled and put in good condition by the use of some old plastic covering taken off an old, unused steam line. This class of covering will stand remixing and make a good job.

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*Master mechanic C. P. R. Mines, Lethbridge, Alta., Canada.

The boiler settings were also gone over and all air-holes and cracks in the brickwork were plugged.

One of the largest single losses around the plant was caused by the location and design of the steam header serving the power-house engines, etc. This header included about 125 ft. of 16-in. o.d. pipe, and 75 ft. of 12-in. pipe. There were also several 6-in. and 8-in. branch pipes leading to the various engines. All this piping was installed outside and directly under the drip off the roof. The large 16-in. flanges had never been covered, and the covering on the pipes was poor. Nearly every flange leaked at the threads, and the condensation, as shown by the leaks, was extremely high, as was to be expected in a locality where the temperature takes big drops for days at a time. The header, as installed, required 60 to 70 per cent. more pipe than if it had been put up inside the power house.

As it was impossible to make any repairs to the header and at the same time keep the plant in operation, a new header was installed inside the power house. It was made up of pipe on hand and a few of the fittings out of the old installation. Instead of making the new header of 16-in. pipe, which was large enough for three or four power houses of the size served, pipes 12, 10 and 8 in. in diameter were used. This reduced size also facilitated drainage owing to the increased velocity of the steam. Sufficient lagging to cover the new header was secured from some old unused boilers. It was in slabs 6 x 36 in., but by splitting into 3-in. widths it made first-class pipe covering.

One of the two tandem-compound generator engines was in bad condition owing to the low-pressure piston and cylinder having worn enough to let the piston rod drop about one-eighth of an inch. The engines were of the horizontal type. This was remedied by fitting the low-pressure piston with two bronze wearing rings, and all four packing-boxes with bronze neck-bushings. New piston rings were also put on, as the old ones had been passing steam badly. The low-pressure cylinder should have been bored out, to make a first-class job, but at the time the work was being done it was impossible to risk stripping the engine. While the low-pressure piston was being machined for the rings, the engine was run on the high-pressure end only and carried the load all right. After over two and a half years' running the piston rod on this engine had dropped again only a distance of 0.008 inch.

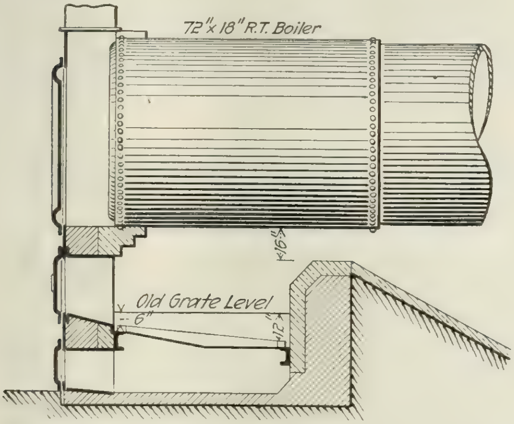


FIG. 2. BOILER SETTING SHOWING OLD AND NEW GRATE LEVEL

The other generator engine had a bent piston rod and badly worn piston rings. These were renewed and the piston given a one-quarter turn to bring the wear on a new section of the wearing rings.

There was between 15,000 and 16,000 lin.ft. of 1-in. pipe built into heating coils in the washhouse. The condensation from these coils had been allowed to blow to waste through a hand-regulated valve. Of course the valve was always left open enough to insure draining the coils "in case it happened to get a little colder."

To get the benefit of this condensation for feed water, a good steam trap was connected up to the outlet header of the coils. A bypass was also included, and in case the trap got out of order during the night, the watchman simply regulated the drainage in the same way as before. The hot returns were discharged into a tank that fed by gravity into the open feed-water heater; some particulars of the connections to this tank are given later on.

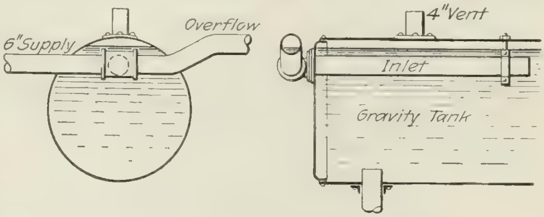


FIG. 3. PIPING TO GRAVITY TANK

The trap used discharged about two gallons per dump, and the writer often counted the number of discharges at twice a minute on the coldest days, down to once every four or five minutes on the average days. This was a big difference to steam blowing steadily through the old drain valve.

With about 600 men washing daily in this washhouse, a large amount of hot water was required, and a large amount was wasted. This water had always been heated by live steam in an overhead tank. To make it worse, the tank usually overflowed "to make sure that there was plenty of water." To cut out this waste, the live steam was shut off and the exhaust from one of the boiler feed-water pumps turned in. As one pump was always in operation, there was no chance of the exhaust being shut off for any length of time.

In making the change of piping to this hot-water tank, the queer ideas of some men with regard to simple questions in engineering were forcibly brought home. Someone in former years had put a large steam coil of 2-in. pipe inside the tank, with the drain of the coil piped outside to a trap on the ground below. The trap froze up one night and the coil broke at a return bend. After that the coil was allowed to drain into the tank through the break.

A cold machine shop is about the poorest place on earth to get any work done. The heating of the shops in this plant had been done by stoves, but no one seemed to think that the heating really had been done.

To make it right, steam coils of old 2-in. pipe were put around practically the entire walls to a height of about three feet from the floor. A connection was then made for the exhaust steam from the shop engine to be used during working hours. At nights and at other times when the engine was not running, live steam through a reducing valve was used at about 10 lb. pressure. To prevent any chance of the coils freezing up due o drain valves being left closed, and also to eliminate any fussing in adjusting the opening of these drains, a hole about [illegible] in. in diameter was drilled through the gate of each valve. In the mornings the shop boy shut off the reduced steam, then opened the drain valves wide and turned the exhaust steam into the system. At nights he reversed the procedure, and instead of having to set the drain valves to a required opening, he simply shut them. The small holes were sufficient to keep the coils drained with the pressure at ten pounds. Of course there was a little steam wasted in this way, but simplicity and reliability were the most important factors in this case.

Exhaust-steam heating was also put in two of the fan-engine rooms and locomotive sheds. As the fan engines ran 24 hours a day practically every day in the year, conditions were ideal for exhaust heating. Before the heating coils were installed in the engine rooms, there was difficulty in keeping the oiling system in operation on cold days.

To provide for a uniform head-pressure to the water going to the feed-water heater, an overhead tank composed of an old boiler shell had been installed. This was good as far as it went, as every engineer knows how much better a heater float-valve works with a uniform pressure than with a varying one. To supply the tank with water, the air-compressor jacket water had been piped to it and entered at one end and overflowed at the other. As this system would waste the hot returns from the steam traps at the washhouse and the power house, the traps being piped to discharge into the tank, it was decided to change the jacket-water piping in such a way that the tank would not overflow and yet keep a uniform water level.

It was first intended to use a float valve on a branch pipe from the jacket-water outlet header to supply the tank. However, after considering the natural troubles that go with most float valves, and trying one, this method was passed up for simple piping system shown in Fig. 3. The solution was so extremely simple that it is surprising that it had not been thought of sooner. The idea may be of use to someone wishing to use all or a portion of some waste water.

As some of the outside steam pipes were leaking badly, they were overhauled and thoroughly covered for below-zero weather. One old line about one-third of a mile long, was made up of 8-, 6- and 4-in. pipes and apparently all the different fittings that could possibly be connected up. It was jogged up and down and sideways, and had several good water pockets that furnished periodic slugs to the engines it served. Several hundred feet of the 4-in. size was laid on the ground alongside of the car track, and had been found very handy to get rid of snow shoveled off the track. This and the rain had soon fixed the pipe covering.

This 4-in. section was relaid on trestles and properly covered. It was given a 1 per cent. grade and a steam trap connected at the far end for proper drainage. The other part of the line, which had so many fittings and jogs in it, was replaced by a new 6-in. line. Bends were used instead of the three or four slip expansion joints. These joints had been the cause of several shutdowns of the fan engines to allow them to be repacked. The water lying in the line seemed to make the life of the packing uncertain, and the result was either bad leaks or a shutdown at the first opportunity. This was all the more annoying because the fan engines were run a year with only one stop of a few hours for keying up and packing after the new steam line had been put into use.

In going over a plant with a view to economy, it is well to remember that it is the accumulation of small defects and leaks that counts as a rule. In the plant under consideration, although the coal consumption was reduced, the output from the power house had considerably increased.

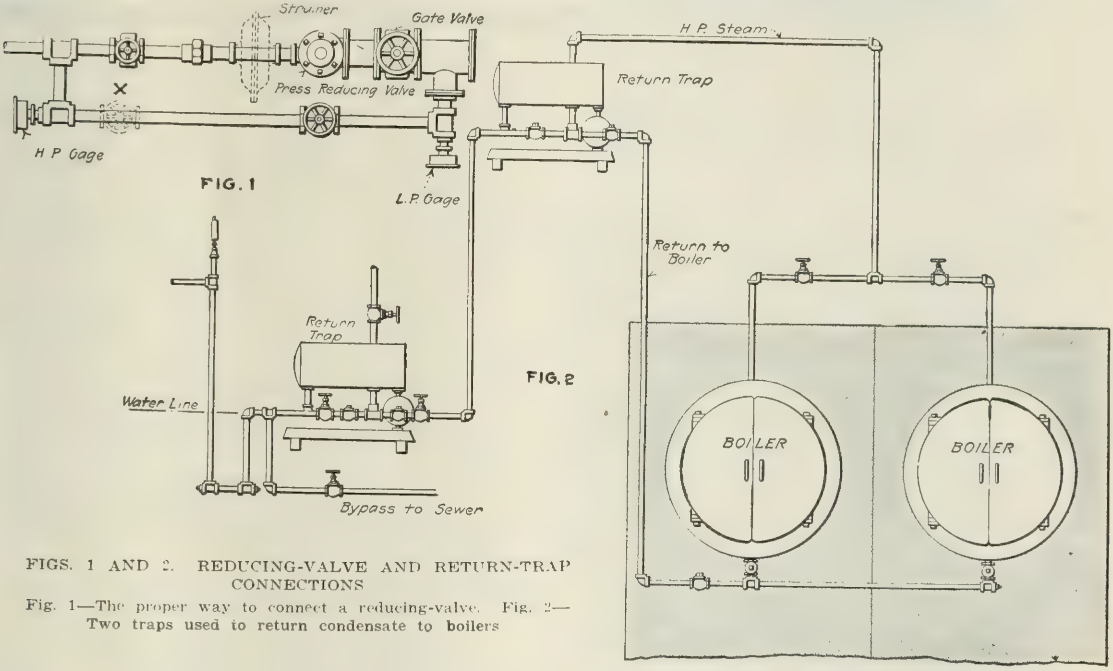
Care of Heating and Ventilating Equipment—X

BY HAROLD L. ALT

ANY heating system may be supplied with steam through a reducing valve instead of directly from a boiler, but the proper modifications must be made to care for the returns. To operate satisfactorily some sort of an automatic device is necessary to admit just sufficient steam to the low-pressure line to maintain the pressure there required—say 5 lb. gage or less. This is accomplished by a pressure-reducing valve which is closed by the pressure in the heating main when it becomes greater and opens when the pressure becomes less than that for which the valve is set. The action of a pressure-reducing valve is similar to, and in fact is, a throttle valve automatically controlled. The method or means of control varies in different makes and is usually either a diaphragm, differential or spring, or a combination of these means. The diaphragm type of pressure-reducing valve consists of a balanced valve the spindle of which is connected to a diaphragm. Movement of the diaphragm varies the opening to meet the demand for steam and is produced in one direction by means of a spring tending to open the valve while steam pressure in a chamber on the other side of the diaphragm, connected through a pipe to the low-pressure main, works against the diaphragm and spring and tends to close the valve. Thus the steam pressure on the diaphragm in one direction and the spring pressure in the opposite direction are opposed to each other, and any increase in the steam pressure tends to overcome the spring and close the valve.

The differential valve has two disks, one of small diameter and one of large diameter, mounted on the valve spindle in such a way that the high-pressure steam is against the small disk, tending to open the valve, while the low-pressure steam acts against the larger disk and in the opposite direction and tends to close the valve. Thus the pressure carried in the low-pressure main will be proportional to that carried in the high-pressure main, determined by the relative area of the two disks. A variable high pressure will therefore affect the low pressure. Spring-operated valves are counterbalanced by springs and the pressure in the low-pressure line combined. An increase in pressure closes the valve by assisting one spring, while a decrease in pressure allows the valve to be opened by the other spring. Weights are sometimes used instead of springs to oppose the action of a diaphragm in some types so that the farther out on the lever arm the weight is placed the greater the pressure that must be exerted under the diaphragm by the steam from the low-pressure main in order to close the valve.

It is best in installing a reducing valve to arrange the connections with a bypass as shown in Fig. 1, and if the valve is not supplied with an integral strainer a separate strainer, shown dotted, should be provided. In order to keep the close connections around the valve tight, it is considered essential by some that the bypass valve be located at a point exactly opposite the pressure-reducing valve, owing to the unequal expansion that otherwise occurs. For instance, suppose a bypass valve is located at *X*, the distance from the point of connection to the reducing valve is so much greater than the distance to the bypass valve that the difference in the temperature between the high-pressure and the low-pressure steam expands the main line more than the bypass due to this extra length. When the valves are opposite, the expansion in both the main line and bypass is equal. In any case, however, there should be adequate provision for expansion.



FIGS. 1 AND 2. REDUCING-VALVE AND RETURN-TRAP CONNECTIONS

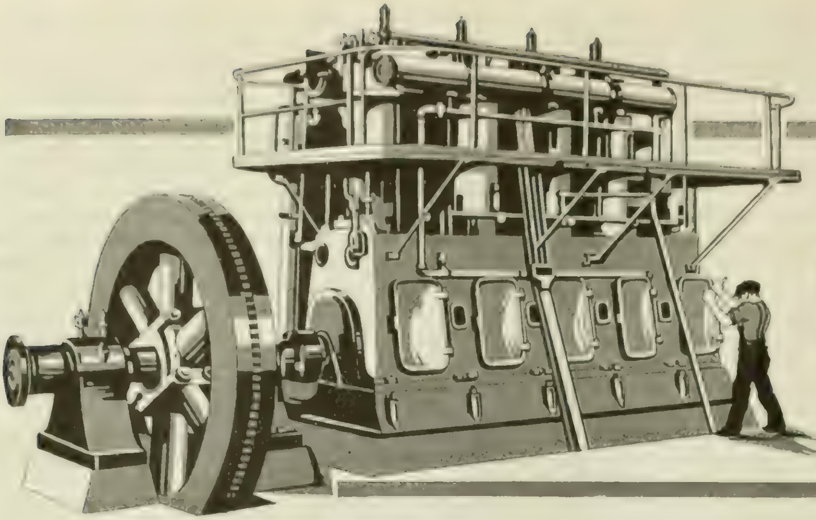
Fig. 1—The proper way to connect a reducing-valve. Fig. 2—Two traps used to return condensate to boilers

Having provided for a supply of steam, the other problem is to take care of the return. There are several methods of handling the returns, the chief deciding factor usually depending on how they can best be utilized in the particular case. Usually, the returns are discharged through a trap into an open feed-water heater, run to a receiver and pumped back to a suction tank or feed-water heater or are discharged through a trap to the sewer and wasted. It is possible to return the condensation directly to the boilers by the use of a return trap set well above the boiler line, as shown in Fig. 2. Automatic air-vent valves should be located on the return line to let out the air, for traps will not work if airbound. Condensation from a low-pressure heating system may of course be returned by an ordinary boiler-feed pump or a receiver pump taking its suction from a small cast-iron tank or receiver containing a float which controls the speed of the pump, starts it whenever the water reaches a given high level and stops it when the receiver has been nearly emptied. Such pumps may return the condensation directly to the high-pressure boilers, but usually return it to an open feed-water heater or reservoir. Sometimes where water is cheap or where the cost of getting the return water back is greater than the heat contained in it is worth, it is allowed to discharge through a trap to the sewer. This is not economical, however, from an engineering viewpoint. This trapping may be done by connecting all the radiators to a common return line and placing a trap at the end of the line, or the radiators may have individual traps and their returns connected in groups, leaving the return line open to the atmosphere, making practically an open waste line of it.

To connect up a heating system to return the condensation to a high-pressure boiler, it is desirable to use two "return" traps, while to return the water to an open feed-water heater or tank at a high level one return trap will be sufficient. If the water heater or tank is at a lower level, an ordinary "dump" or "separating" trap will answer. A trap will discharge water above its own level approximately two feet for every pound of steam pressure applied above the water in the trap to operate or empty it.

Having gotten the water into a return trap set higher than the water line in the boiler, it can readily be discharged into the boiler when steam at boiler pressure is admitted to the trap assisted by the hydraulic head. It is only necessary to make the vertical distance sufficient to produce the head necessary to overcome the pipe friction for the water to flow into the boiler.

On the vacuum steam system the vacuum pump usually discharges into the air-separating tank or open heater and the water is then pumped to any point desired.



Talks on DIESEL Engines

by L. H. Morrison

XVII—Egan confines his remarks to cooling-water systems, describing various methods of cooling, forms of cooling towers, and troubles caused by scale.

"WE ARE going to take up cooling systems tonight," Egan announced, "and so we'll have three to consider. The first is the closed-circuit pump-feed system, like I've outlined in Fig. 1."

"That's the way we piped up our hot-ball engine," Woods declared.

"No doubt," assented the chief. "It's good for small powers only. The water is stored in the basin *A*, from which it's drawn by the pump *B*, driven by the engine, and forced through the engine jackets and heads. It is then discharged over the cooling tower *C* and drops into the basin *A*."

"Why won't it do for big engines?" one of the men asked.

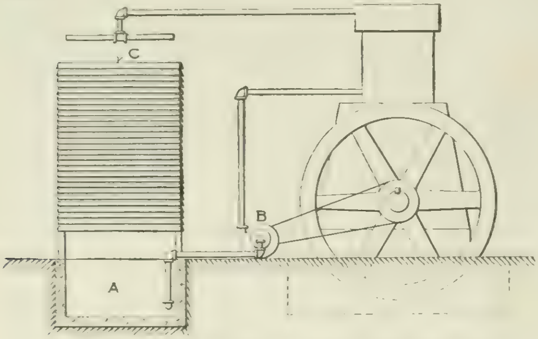


FIG. 1. CLOSED-CIRCUIT SYSTEM OF COOLING

"If I were to tell the truth, I'd say that it isn't suitable for any engine. It has one redeeming feature—that of simplicity. It is not necessary to install a high storage tank. The cooling tower need be but a few feet above ground; as a consequence the pressure head on the engine jackets is very low. The piping is cheaply installed and can be understood by the greenest of engineers. The one damning feature is the engine-driven circulating pump."

At the next meeting the men will discuss the status of the Diesel engine and the outlook for engineers trained to run this type of engine

"Why so, chief?" Kelly asked. "If the engine runs, you're sure to get the water."

"You've said it, Kelly. If the engine runs, you'll get the cooling water. But how about the water when the engine is stopped?"

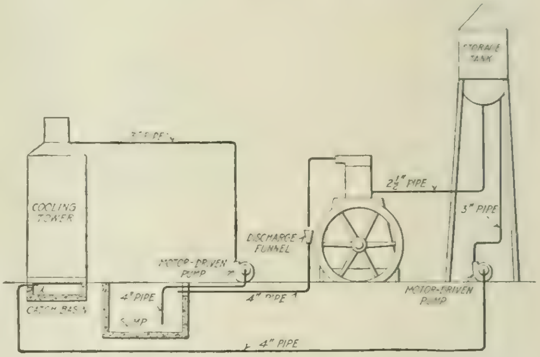


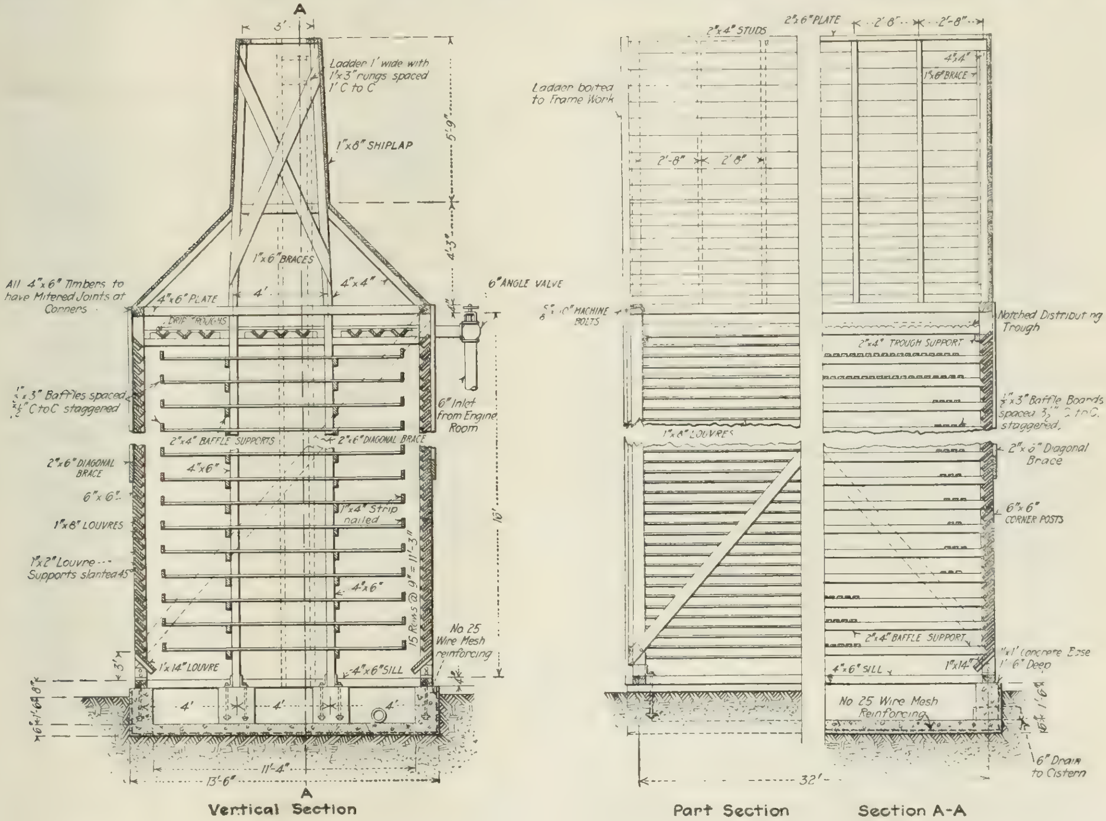
FIG. 2. DIAGRAMMATIC OUTLINE OF ENTIRE COOLING SYSTEM

"I'll bite. What's the answer? I know you've always ordered us to let the cooling water run for twenty minutes after we shut an engine down, but I always thought that was wasting water."

"Instead of being wasteful, that order really is an aid to conservation—of the engine. When the engine is running, part of the heat developed is absorbed by the cooling water, but this heat is first taken up by the piston and cylinder walls. When the engine is running properly, therefore, the jacket water is taking heat from the metal walls just as fast as they are absorbing it. Now, if you stop the engine and the flow of cooling water at the same time, there is a considerable amount of heat stored up in the piston and the cylinder walls. There is no water circulation to remove it, and the heat is conducted to adjoining parts of the engine that were not intended to withstand temperature stresses. As a result there may be warping or cracking, and seizing of the piston is another difficulty that may follow. The lack of cooling water after stopping also explains why piston-pin brasses get hot and grip the pins.

"You can see now that this system is not good for large engines. Small engines have about the same clearances as large ones, and as the expansion is less, there is less danger of seizing. But if you must use this system on an engine, be sure to use a piston or plunger pump and never a centrifugal."

"I don't agree there, J. R.," Woods began. "A centrifugal pump has the fewest parts and is nearly foolproof. It has no piston packing rings to bother with, and about all you need do is to put in a little packing around the shaft once in a while."



Vertical Section Part Section Section A-A

FIG. 3. DETAILS OF WOODEN COOLING TOWER OF EXCELLENT DESIGN

Egan smiled tolerantly at the younger man.

"Of course," he admitted, "if all you want is a large amount of water pumped without much attention, a centrifugal pump is O. K. But you must remember that a centrifugal pump has to be primed. Suppose your suction line began to leak air into the pump. It would lose its suction, and the flow of water would stop. If you failed to notice this at once, first thing you'd know you'd have a fractured cylinder head or a scored cylinder. But if a piston pump loses its suction by stopping of the engine, it will pick up again, since it will prime itself. Repacking plungers isn't serious, and the guarantee of positive water circulation offsets the extra work."

"How about the water pit, chief? I've heard that this plant is the only one of the company's that sports anything but a wood sump tank."

"That's because the other plants are only enlargements of old plants. They all had earth tanks, lined with 2 x 8-in. timbers, but until recently, they weren't big enough to justify a new tank as long as the earth tanks held up. When we put in the new engines, we had to install a storage tank, and so we got the concrete one. However, it is merely a sump to catch the water as it flows from the engine discharge. Our cooling tower is laid out like Fig. 3, which shows an excellent design.

"Fig. 2 will give you an idea of the layout of the entire system. A motor-driven centrifugal pump is used to lift the water from the sump to the top of the cooling tower. From the catch basin a motor-driven centrifugal pump lifts it to the 50-ft. steel tank and it then flows down through the engine. The tank holds 25,000 gal., or enough to supply all the engines for two hours in case anything goes wrong with the pumps. To beat Kelly to his question, I'd say that the centrifugal pumps are used since the storage tank and tower provide ample water for a long time even if one of the pumps should fail to work.

"The pump to the overhead tank is automatically controlled by a pressure-operated switch that causes the pump to stop when the water level is a foot from the top of the tank and to start up again when the level is two feet from the bottom of the tank. This cuts down the amount of power used by the pump motor and prevents any overflow loss of water. As an extra precaution, I installed a bell and light alarm, as in Fig. 5.

"In the steel tank I fixed a ½-in. iron rod *A*, over which was slipped a length of ¾-in. pipe *B* fitted with two collars and a float free to slide up and down on the pipe. A collar *C* is fixed to the end of the pipe and is held between the springs *D* and *E* that bear against the supporting bracket. Thus the pipe is held suspended, although it may be moved slightly up or down. The collar *C* carries an insulated lug *F* to which is attached one side of the electric circuit. Two insulated contact fingers *G* and *H* are fixed to the bracket and connected with the other side of the circuit through lamps of different colors. When the water gets too high, the float hits the upper collar, lifts the pipe, makes contact with the finger *G* and rings the bell and flashes the green lamps. When it gets too low, the float hits the lower collar and the lug *F* makes contact with the finger *H*, flashing the red lamps and ringing the bell. The contact fingers are made with springs to protect them from breakage in case the pump fails to start when the float strikes a collar.

"The third system is like that in Fig. 2 except that it uses a spray cooling pond in place of the cooling tower. Some plants operate this as a closed system and force the water under pressure through the jackets and out through the spray heads, which calls for a pressure of about 30 lb. However, it is my opinion that every cylinder should have a separate discharge, as should also the air compressor, the intercooler and the valve cages. The discharge lines should run into a common funnel. It is then easy to see if all the lines are open and flowing. With a closed system, one cylinder jacket could be stopped up and the single discharge at the pond would go on flowing as usual, so that there would be no indication of the trouble to warn the engineer.

"It is my opinion that the spraying system will become the standard before long. It occupies no more room than a cooling tower and pit and the water is cooled to a lower temperature than is possible with a tower. The lower temperature obtainable is undoubtedly due to the finer subdivision of the water and the more intimate contact with the air."

"J. R., what should a plant do that isn't large enough to afford the steel tank and tower?" Woods wanted to know.

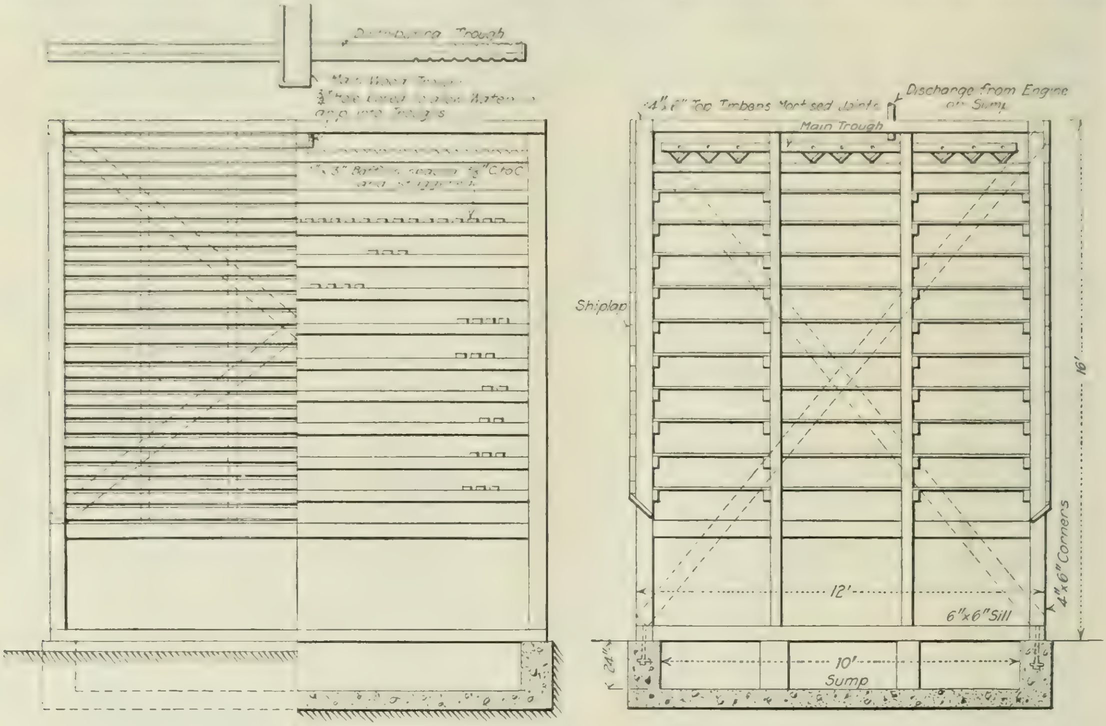


FIG. 4. INEXPENSIVE FORM OF CONSTRUCTION FOR WOODEN COOLING TOWER

"In such a case a tank 12 x 14 ft. constructed of 2-in. cypress and holding about 12,000 gal. is cheap and lasting. Such a tank should be mounted on a 30-ft. wood tower built of 10 x 10-in. oak timbers. This height will give ample pressure to the water. A cooling tower can be cheaply built along the lines of Fig. 4, which is a layout I've installed several times."

"By the way, chief, how much water ought an engine to use?"

"Well," said Egan, "let's look at that problem from a theoretical standpoint and see how it checks up with practice. The specific heat of water is one, and so for every increase of one degree of temperature a pound of water absorbs one heat unit; or, each pound will absorb as many heat units as it rises degrees in temperature. The weight of water required can be found by the formula

$$W = \frac{XH}{100(t_1 - t_2)}$$

in which

W = Weight of water required per horsepower-hour;

X = Percentage of heat absorbed by water jackets;

H = Heat developed in the cylinder per horsepower-hour;

t_1 = Temperature of discharge water;

t_2 = Temperature of ingoing water.

"Ordinarily, the value of X is about 35 per cent. and to develop one horsepower-hour about 9000 B.t.u. must be produced in the cylinder. The temperature of the ingoing water will be around 70 deg. F. and of the discharge water about 140 deg. F. as an average. Under these conditions,

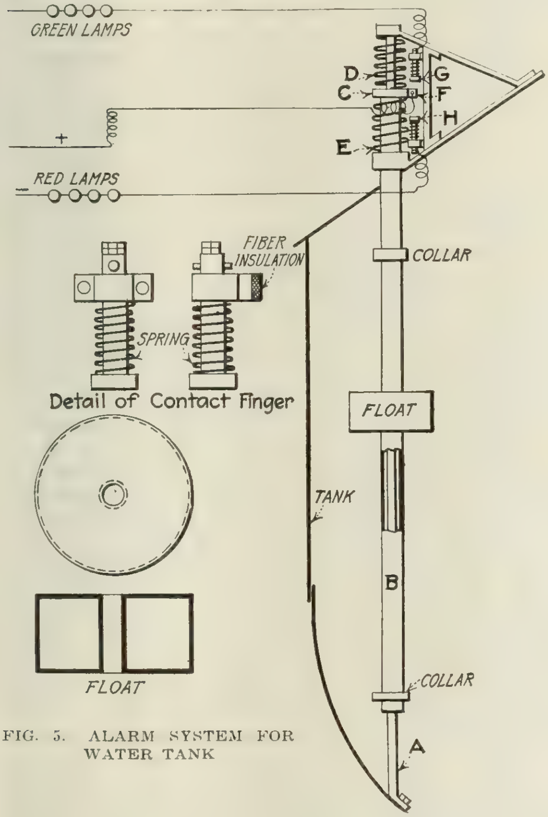


FIG. 5. ALARM SYSTEM FOR WATER TANK

$$W = \frac{35 \times 9000}{100(140 - 70)} = 45\ lb.$$

"There's another point I wanted to mention. In starting an engine, keep the cooling-water valve closed until the engine has fired a few times. The jacket is always full of water that is a little warm anyway, so there will be no danger of cracking it. If you start the cold water through the jacket before the engine begins to fire, the chilling action will make starting pretty hard. Of course, the head will be empty, but it won't warm up at once, so there's no danger of cracking it. But this method demands some attention from the operator. He can't afford to forget to open his water valve. If it is a green bunch running a plant, it's a lot safer to start the water before turning the engine over, although this will probably necessitate starting on kerosene."

"I think you've forgotten the very thing you should have talked about," said Kelly. "I mean jacket scale."

"The joke's on me," the chief confessed. "After all the rumpus I've raised about cleaning the jackets, it's funny that I'd forget it. Some oil-engine plants are so situated as to have pure cooling water, but the majority must use whatever water is at hand, which is generally bad. Ordinarily, the hardness of the cooling water is due to sulphate of lime and bicarbonate of lime or magnesia. The sulphates don't settle out of the water unless the temperature is high. It is with the bicarbonate of lime that we must deal in the main. This will begin to deposit before the temperature reaches 200 deg. F. So it will scale the jackets under ordinary conditions. When the jacket gets scaled up, a 10 per cent. solution of muriatic acid left in two or three hours will cut the deposit so it can be flushed out."

"That seems a hard way. Isn't there a better one, chief?"

"Yes, Kelly. If a solution of soda is used in the sump tank, it will tend to settle the sulphate before it reaches the jackets. Sometimes, when the water is taken from a stream, it will deposit organic matter, but this isn't serious. It's possible to eliminate it by the use of a coagulant, such as iron alum.

"There is another trouble met wherever water is cooled and used over again. If water is passed and repassed through the engine, part of it evaporates in the cooling tower, and all the minerals that came with the original water remain in it. In time the percentage of solid matter becomes so great that part will crystallize and settle in the jackets and pipe as a sludge, which soon bakes as hard as the iron. To overcome this, replenish the entire water charge every 30 days or so. In general, all the average operator need do is to use a little soda, flush the jackets every week, and about every three months use a muriatic-acid solution if scale is in evidence."

Air Booster for Centrifugal Pumps

Two single-stage centrifugal pumps were insufficient to keep down the water at the Algoma mine, Ironton, Minn., when the flow increased owing to the cessation of pumping at an adjoining property, says H. H. Hunner in *Engineering and Mining Journal*. One pump was driven by a 75-hp. motor at 1750 r.p.m., rated at 1290 gal. per min. against a 165-ft. head, and was pumping at approximately this head. The second pump was direct-connected to a 100-hp. motor making 1750 r.p.m., and was rated at 1500 gal. per min., with a 170-ft. head. Suction and discharge for both pumps were 6-in. diameter pipes.

Elbows on the discharge pipes were tapped for 1-in. pipe connections about five feet from the pumps, connected to an air line, and the valves were slightly opened on a 90-ft. air pressure. The added pressure increased the capacity of the pumps by 200 or 300 gal., which was sufficient to take care of the increased flow of water. The small amount of air used was not noticeable on the air line.

The Electrical Study Course—Three-Wire Generators in Parallel

Brings out the factors governing the parallel operation of three-wire generators and describes the method of making connections to the control panels and the details of placing a generator into service and of cutting it out of service.

When dealing with three-wire systems of large demand or having heavy peak loads at certain hours of the day, the same factors govern as in any other electrical system, and it may become necessary or advisable to install several units to supply the load instead of a single one. When such is the case, we are confronted with the problem of the parallel operation of three-wire generators, and it will therefore be well to accord the subject some consideration. Since the compound machine is the one most commonly in use, we will confine our attention to that type.

A diagrammatic representation of two such machines connected in parallel is given in Fig. 1. As explained in the preceding lesson, the series-field windings of compound three-wire generators must be divided into two parts, one of which is inserted between one terminal of the armature and a main and the other between the other terminal and main, as at F_a, F_b, F_c and F_d. Now, in the lessons dealing with compound generators in parallel it was shown that it is necessary to have an equalizing connection joining those terminals of the armatures to which the series-field windings are connected. In the case of the three-wire generator it is therefore necessary to provide two equalizing connections, since both the armature terminals in this case have series-field connections made to them. These two equalizers are shown at Z_1 and Z_2, and connect *a* to *c* and *b* to *d*. The series fields F_a and F_c are connected between Z_1 and the main *A*, and the series fields F_b and F_d are connected between Z_2 and the main *B*. The mid-points g_1 and g_2 of the inductances L_aL_b and L_cL_d are connected to the neutral main *N*.

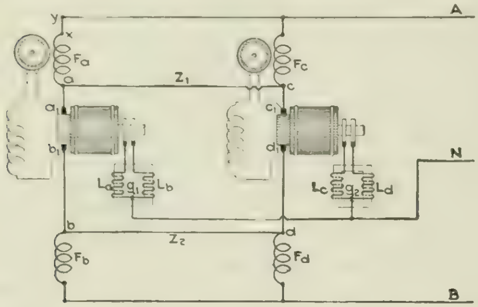


FIG. 1. SCHEMATIC DIAGRAM OF TWO THREE-WIRE GENERATORS CONNECTED IN PARALLEL

The two equalizers function in exactly the same manner as does the single equalizer used when two-wire compound generators are operated in multiple. Thus, Z_1 connects F_a and F_c in multiple and thereby causes whatever current flows in *A* to split evenly between them. Likewise Z_2 connects F_b and F_d in multiple and causes the current in *B* to divide equally between them. In order that such shall be the case, it is of course necessary that the resistance of F_a shall equal that of F_c and that the resistance of F_b shall equal that of F_d, as was explained at the time that compound generators were discussed. Although only two generators are shown in the diagram, it is to be understood that any number of machines may be connected in parallel in the same manner.

The method of operating three-wire compound generators in multiple is essentially the same as that outlined for ordinary two-wire machines. The chief points of difference are that with the three-wire generator we have the inductances to connect to the alternating-current side of the machine and that we must make provision for connecting the mid-point of the inductances to the neutral main at the same time that connection is made between the direct-current side of the machine and the outside mains.

It is also necessary to provide two ammeters for each machine since the current in the two outside mains is not the same when there is current flowing through the neutral. It is also desirable to have a third ammeter to measure the current in the neutral. If one is installed, it should be of the type that has its zero point at the middle of the scale and reads in both directions from the center, since the direction of the current in the neutral may be in either direction, depending upon what side of the system is the more heavily or lightly loaded. The ammeters that are used to measure the currents in the outside mains should be connected between the series field and the armature. Thus, in Fig. 1 the ammeter should be connected between *a* and a_1, *b* and b_1, etc. They will then measure the current actually delivered by the armature.

If the ammeter were to be connected between the series fields and the mains, as for example, between *x* and *y*, the current measured would be that through the series field. Since the currents through all the fields between *A* and Z_1 or between *B* and Z_2 are the same, the reading of the ammeter would be no indication of the load carried by the machine. This condition also introduces a complication when interpoles are used on compound generators. Since the current through the interpole windings must change with the armature current in order to secure good commutation, it follows that the interpole windings must be connected into the same part of the circuit as are the ammeters.

In Fig. 2 is represented one type of control connections for a compound three-wire generator that is to be operated in parallel with others; also the connections between it and the generator, which is of the interpole type. In the figure, *G* represents the generator, F_s its shunt field, F_1 and F_2 the two halves of the series field, and C_1 and C_2 the two halves of the interpole field. The terminal block of the generator is shown at *Y*. The terminals on it are marked with letters that correspond to letters applied to the various terminal points of the windings, such as *e*, *f*, *h*, *k*, etc. The direct-current brushes are designated by *a* and *b*, and the alternating-current ones by *c* and *d*.

From the block Y lines are run to the three switches S_L, S, and S_Z, and to the shunt-field rheostat R. Switch S_L serves to connect the inductances L_1 and L_2 to the alternating-current terminals *cd*. Switch S is for the purpose of connecting the ammeters I_A and I_B between the points *eh* and *fk* respectively and also to connect the middle point g of the inductances to the neutral main N of the system. Switch S_Z serves to connect the series field F_1 between the main A and the equalizer Z_1, and to connect the series field F_2 between the main B and the equalizer Z_2. The ammeter I_A reads the current delivered to main A by the generator, ammeter I_B measures the current delivered to main B, and ammeter I^N measures the current delivered to the neutral main N.

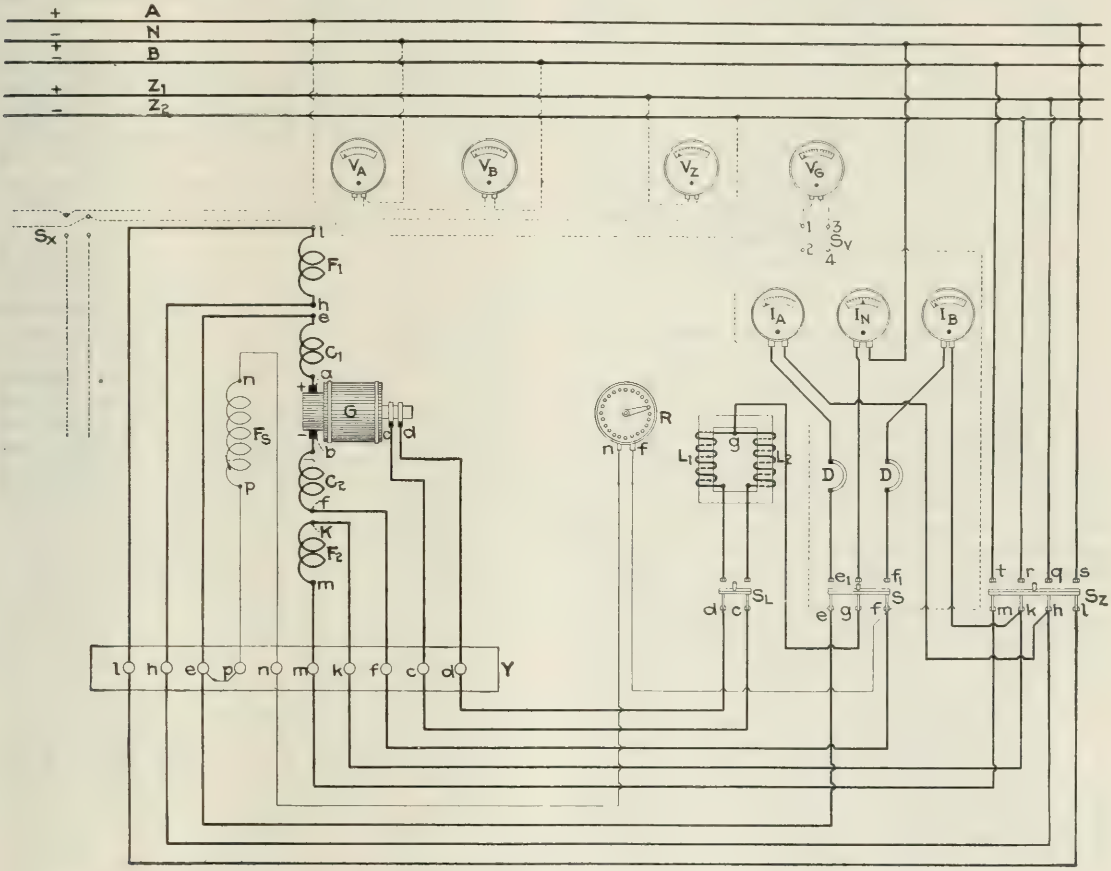


FIG. 2 CONNECTION DIAGRAM OF A THREE-WIRE GENERATOR IN PARALLEL WITH OTHER MACHINES

The voltmeter V_A measures the voltage across A and N and the voltmeter V_B that across N and B. The voltmeter V_Z measures the voltage across Z_1 and Z_2, which is practically the same as that across A and B; it is slightly higher owing to the voltage drop across the series fields connected between A and Z_1, and B and Z_2. Voltmeter V_G is connected to the voltmeter plug switch S_V to determine the voltage across the armature terminals *ef* of the generator. Circuit-breakers *DD* are installed in the armature circuit to protect the generator against overload.

At S_X is represented a voltmeter switch supposed to be situated on another panel; it is shown to illustrate the method of connecting such switches in parallel, so that by the use of one plug for all a single voltmeter can be used for testing the voltages of all the machines on the system one at a time. Dotted lines are used to represent voltmeter connections to make them readily distinguishable from the other circuits.

In order to facilitate tracing out the relative positions and connections of the instruments, etc., a simplified connection diagram is given in Fig. 3. In order to make more clear, in the discussion that follows, the reason for connecting voltmeter V across Z_1Z_2, it is shown connected across the points *qr;* since these points connect to Z_1 and Z_2, the effect on the voltmeter is the same.

In order to place a generator such as that under discussion into service in parallel with other machines on the system, the following would be the method of procedure: At the time of starting all the switches would of course be open. The first step would be to start the machine and bring it up to normal speed. The plug would then be inserted into the switch S_V, thereby connecting 1 to 2 and 3 to 4, which connects V_G across *ef;* that is, across the armature terminals of the generator. Switch S_Z is now closed, causing current to flow through F_1 and F_2 and thereby giving a certain amount of series-field excitation. Thereupon the shunt-field rheostat R is adjusted until the voltmeters V_G and V_Z read alike.

By tracing back through switch S_Z it will be found that voltmeter V_Z connects across e_1f_1. On the other hand, V_G connects across ef. Hence it would be safe to close switch S when the two voltmeters read alike. If V_Z were connected across AB instead of Z_1Z_2, it would be equivalent to having it across st, and it would measure the voltage across e_1f_1 minus the voltage drop through F_1 and F_2; and if the reading of V_G were to be made equal to it, the voltage across ef would be less than that across e_1f_1, in which case the machine would take current from the system if switch S were to be closed.

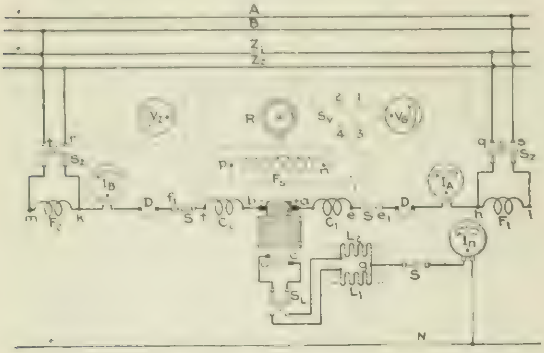


FIG. 3. SCHEMATIC DIAGRAM OF FIG. 2

Having adjusted the voltage as described, the switch S_L is closed, causing alternating current to flow through L_1 and L_2. The current taken by the inductances is so small that it should have no effect on the voltage of the generator. The next step is to close switch S, thereby connecting the generator to the bus. If the voltage has been carefully adjusted, the generator should neither deliver nor take any current. To make it assume its proper share of the load, resistance is cut out of the field rheostat R, thus increasing the excitation, until the ammeters indicate that it is delivering as much current as the other machines.

To take the machine out of service, the foregoing operations are performed in the reverse order. That is, the field resistance is increased until the excitation has been reduced to the point where the ammeters show no readings. Switch S is then opened, followed by switch S_L and switch S_Z, after which the set is shut down.

The control panel for each generator has upon it all the apparatus shown in Fig. 2, except the four voltmeters V_A, V_B, V_Z and V_G. These are common to all the panels and are usually mounted on swinging brackets at the end of the switchboard so that their indications may be read from any part of the board.

The problem of the preceding lesson was intended to show that a voltmeter will give readings of a high degree of accuracy when used to measure voltage drops across resistances whose resistance is small as compared with that of the voltmeter itself. Two resistances R_1 and R_2 of 7 and 15 ohms resistance respectively were connected in series across a source of 110 volts as in Fig. 4. It was required first, to compute the voltage existing across each resistance, and secondly, to determine what the readings of a voltmeter whose resistance is 14,372 ohms would be if connected across R_1 and if connected across R_2. The voltage across each would be the current through it multiplied by its resistance. Thus, if I is the current (which is the same in both since they are in series), E_1 the voltage across R_1 and E_2 that across R_2, we have, $E_1 = IR_1$ and $E_2 = IR_2$. To find I we must divide the sum of R_1 and R_2 into the voltage across them, or, $I = \frac{110}{R_1 + R_2} = \frac{110}{7 + 15} = 5$ amperes. Substituting in the expressions for the voltages gives us, $E_1 = IR_1 = 5 \times 7 = 35$ volts, and $E_2 = IR_2 = 5 \times 15 = 75$ volts. Our computation is seen to be correct since the sum of E_1 and E_2 proves to be equal to the applied voltage; namely, $E_1 + E_2 = 35 + 75 = 110$ volts.

When the voltmeter is connected across R_1 the conditions are those of Fig. 5. That is, we have a resistance of 14,372 ohms in multiple with one of 7 ohms, the two in multiple being connected in series with 15 ohms across 110 volts. The voltage across ac will then be equal to the product of the combined current in R_1 and R_V and their parallel resistance. If R_p be used to represent this resistance, we have, $R_p = \frac{1}{\frac{1}{R_1} + \frac{1}{R_V}} = \frac{1}{\frac{1}{7} + \frac{1}{14,372}} = 6.9966$ ohms. The combined current through R_1 and R_V will be R_p plus R_2 divided into the voltage of the circuit, or, $I = \frac{110}{R_p + R_2} = \frac{110}{6.9966 + 15} = 5.0008$ amperes. Since the voltage across ac is $E_V = IR_p$, we have $E_V = 5.0008 \times 6.9966 = 34.9886$ volts.

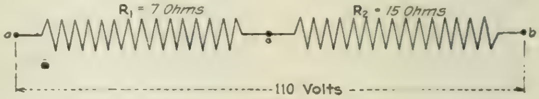


FIG. 4

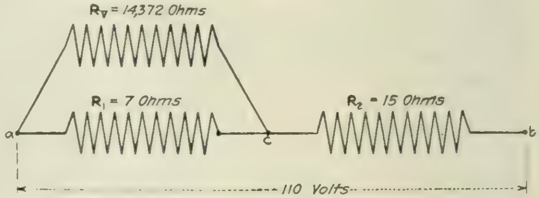


FIG. 5

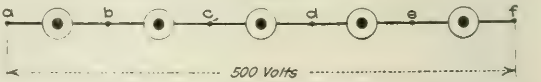


FIG. 6

FIGS. 4 TO 6. RESISTANCE CONNECTIONS

Applying the same method to the case in which the voltmeter is connected across R_2, we have, $R_p = \frac{1}{\frac{1}{R_2} + \frac{1}{R_V}} = \frac{1}{\frac{1}{15} + \frac{1}{14372}} = 14.9844$ ohms. and $I = \frac{110}{R_p + R_1} = \frac{110}{14.9844 + 7} = 5.0035$ amperes, from which $E_2 = IR_p = 5.0035 \times 14.9844 = 74.9744$ volts.

The discrepancy between the actual voltage existing and that indicated by the voltmeter is, in the first case, 35 — 34.9844 = 0.0156 volt, and in the second 75 — 74.9744 = 0.0256 volt. The degree of error in the first case would therefore be $\frac{0.0156}{35} = 0.000617$, and in the second $\frac{0.0256}{75} = 0.000341$. To express in percentages we would multiply by 100, which would give in one case an error of 0.0617 per cent., and in the other 0.0341. Inasmuch as few instruments are guaranteed for an accuracy exceeding 0.1 per cent. and many for an accuracy of only 0.5 per cent., it is apparent that the errors due to introducing the voltmeter in the foregoing case is insignificant and may be ignored.

Five 50-watt lamps are connected in series across 500 volts, as they would be in a street car for instance. This condition is shown in Fig. 6. A voltmeter whose resistance is 50,000 ohms is used to test the voltages across the lamps. What discrepancy would exist between its reading and the true voltage when connected across *ab* and when connected across *ad?*

Short Courses for Engineering Graduates

By J. O. Kammerman*

Those who have followed the engineering profession for the last ten or fifteen years will remember that only a short time ago men graduated from four-year courses in engineering were offered apprenticeship courses by the large manufacturing establishments. Also it should be recalled to mind that the pay offered to apprentice engineers was from seventeen to twenty cents an hour. When the wage of the apprentice engineer was compared with that of a common laborer, in most instances the laborer was getting the better pay.

When a comparison of work was made, the physical labor the apprentice was called upon to do was about as much as the common laborer did; but the work done by the apprentice called for a certain amount of skill and some technical knowledge, which was not required of the laborer. It is true, the apprentice was learning something, while the laborer was methodically moving like a mechanical device.

The apprentice continued to work for a more or less definite length of time in one department and was then shifted to another, where he again began to absorb knowledge and at the same time do a considerable amount of physical labor. By this method he finally obtained a working knowledge of the routine in each department of the factory. The time required was from two to three years.

During this period small increases in pay were effective, but the apprentice usually found his financial resources no larger at the end of his course than when he started. He has been limited in entertainments on account of his lack of funds and often has had to call upon home folks to help him meet financial obligations. To the young man who has left college with the idea of getting a start in this world and creating a fund to start his own home, the aspect at the end of his apprenticeship is not very bright. In fact, the only redeeming feature is that he can say he is no longer on the apprenticeship course. He is given a "white-shirt job" in the front office, where his chief responsibility is checking some calculations or plotting curves. After a year of this, so little real engineering has been done by the average man that he wonders why he ever spent four years in a university, and he feels that he could have saved that time by starting in the apprenticeship course without his college education.

It has been said that for some time after an apprentice starts his course he is an expense to the company. The company needs engineers, and in order to train them it goes to some expense to obtain men for its apprentice courses and willingly pays a wage that is more than they earn. This is kept up till the man is trained and the longer he is on the course the more valuable he is to the company. Evidently the company must pay a scale of wages that will return to it by the end of the training course the money lost during the first period of training. As the period during which the company pays less than the apprentice is worth comes at the end of the course, the apprentice has forgotten the earlier period of his training and feels dissatisfied with his salary, which is a condition beneficial neither to the apprentice nor to the company.

It is the writer's firm belief that the average number of men who have taken apprenticeship courses and have reached a salary of $4000 a year due to their engineering ability is far less than the average number of men who started out from college to be engineers in as short a time as possible, and not by a more or less routine method, and who are receiving $4000 or more per year.

During the period of the active hostilities between the United States and Germany and the period previous when the world war was being fought, engineers were in great demand. Salaries were abnormally high. Men were secured for engineering positions at any price. Many young men, leaving college, were paid salaries ranging from $100 to $150 per month. It is interesting to note that these men, feeling their responsibility, developed characteristics of initiative, resourcefulness, leadership and self-confidence that no apprenticeship course could give. These characteristics are required of the engineer of today, and any course of procedure that does not tend to develop them is not developing engineers. If during the stress of a war period these men can successfully fill responsible positions requiring engineering training, why is it necessary in times of peace to require a prolonged period of training?

Men Rapidly Trained During Period of Great Demand

Employers have said that they must train their own men; yet these same employers took untrained men and in a very short time had then trained for responsible positions. Few, if any, teachers of engineering will say that graduates are experienced engineers. But if during a period of great demand a man can in a few weeks rise to a position requiring ability, why is it necessary during peace times to keep a man on a laboring job until some accident happens and he gets a real position either with the company whose apprenticeship course he took or with some competitor?

These questions are being raised and the men who complete engineering courses this spring are going to question seriously the advisability of a long apprenticeship course. The war has taught many lessons. The intensive vocational courses demonstrated what could be accomplished in a short interval. Men were trained in a very brief time to do certain tasks requiring some skill and special knowledge.

One claim made in support of a long apprenticeship course is that many college graduates do not know what branch of engineering they wish to pursue and that the training course affords an opportunity to make an effective choice. This may be true, but too many men are so discouraged with engineering in general at the end of two years of manual labor that they cannot make an effective choice.

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The writer wishes to advocate several short intensive courses, each course to lead to a definite branch of engineering. The student apprentice should make his choice when he is starting his career. At the end of the short course a position carrying some responsibility should be given to the student engineer. His pay should be commensurate with his training and ability and not a starvation wage. If the course is properly handled, those in authority will know the man's value at the end of six months as well as at the end of two years, and if he is unfitted for the work he has chosen he should be told at once and not allowed to work two years and then find he is on the wrong track.

Coöperation between college faculties and those in charge of courses for student engineers will be helpful. College courses must be changed to include more engineering work and these changes can be made so that the student of engineering will receive in college that which is now part of a student apprenticeship course.

With the college faculties weeding out the men unfit for engineers and the larger companies eliminating the undesirable men at the end of six months of training, the engineering profession would be greatly helped. The standard would be materially raised.

Cat's Six Thousand-Volt Ground Creates No Disturbance on the System

By Frank Gillooly

The top of an oil switch as the nesting place for her brood proved a tragic choice to a cat trespassing in a 6000-volt substation. Indiscretions with high voltage frequently have been made by various animals from rats to squirrels, invariably with disastrous results to the apparatus and the service.

THE CAT TOUCHED THE "C" PHASE LUG

In a substation where the switch gear is located in the basement and controlled from the main floor the operator was making frequent visits to the basement during the night, to make tests on a cable that had failed the day before. Investigating a burning odor on one of his trips, he found a cat's paw on the floor and the feline herself stretched rigid on top of the bus structure near some bare 6000-volt contacts. The two-phase 6000-volt 60-cycle bus is housed in a closed concrete structure about four feet high. Above it, on vertical marble panels, are the disconnect blocks; and near the ceiling, the oil switches.

The cat had traveled the length of the room to its darkest part, mounted the bus structure, and standing on an angle iron, touched the "C" phase lug of one of the disconnecting switches, apparently intending to leap from the top of the panel to the oil switch, which looked warm and cozy and out of sight near the ceiling. The copper lug and the iron were slightly blistered. The cat's front paws were burnt off close to the body, and her body was singed from the flame.

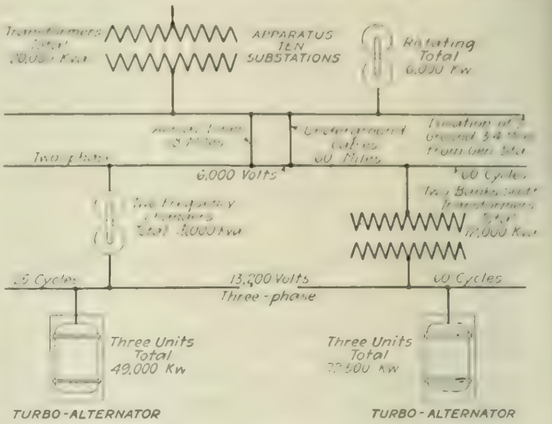


DIAGRAM OF SYSTEM WHEN TROUBLE OCCURRED

The interesting feature is that no disturbance was caused on the system, which had units aggregating 121,500 kw. on the line in its several generating stations, all interconnected through transformers and frequency changers, as shown. All substations are equipped with electrolytic arresters, most of them within sight or hearing of the operator, yet no arrester spill was noticed, nor was any mark made on the voltmeter charts. Three factors, probably, were responsible for there being no disturbance on the system:

1. The high resistance of the ground circuit through the cat's body, and the fact that this circuit was quickly broken when her upright position caused her body to be hurled clear of the contacts.
2. That there was no 6000-volt generator on the line. The accident occurred at 5:00 a.m. when this system, carrying 14,000 kv.-a. load, was being fed through two frequency changers of 15,000 kv.-a. total capacity, and two banks of Scott transformers of 6000 kv.-a. each.
3. That the system had been combed of leakage grounds when, at the same hour on the preceding morning, one cable had failed, its relays failed to function, and it had caused three other cables to fail and both the frequency-changer and the transformer switches to trip and kill the whole 6000-volt system.

Carbonization of lignite, which is absolutely essential to its more general use, is strictly in accordance with modern scientific research. We are simply, from necessity, starting to do with lignite now what will eventually be done with all of our high-volatile coals.

Dravo Superheater

In the more advanced countries of Europe no power plant is operated today, if it is of any considerable size, without superheated steam. In this country it is common to find large plants using saturated steam, although this condition is rapidly changing with regard to the more up-to-date plants, where superheated steam is used in connection with the turbine installation.

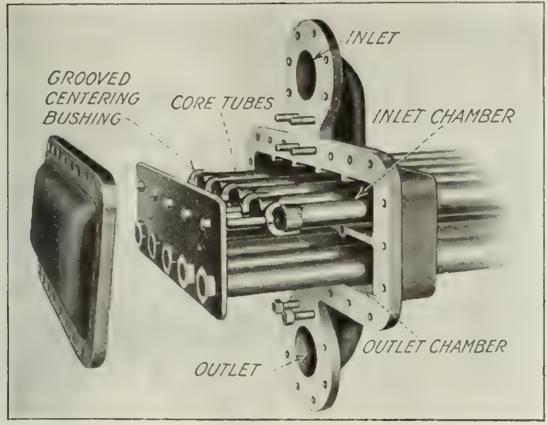


FIG. 1. SHOWING CONSTRUCTION OF SUPERHEATER

The Dravo superheater, manufactured by the Superheater and Engineering Co., 233 Broadway, New York City, is so built that the steam is agitated as it passes through the apparatus and is thereby brought into direct contact with the hot surface of the tube, which tends to produce a uniform degree of superheat at the outlet. The superheater is designed to conform to the code covering such apparatus, as adopted by the American Society of Mechanical Engineers. Details of its construction are shown in Figs. 1 and 2.

The steam enters either at the side or at the end of the header, as may be convenient, passes into the inlet chamber, thence into the annular space between the tube and core pipe of the ingoing element, both by way of the grooves and the bushings and through the core pipes themselves, passing through the connecting pieces, or return bends, into the outgoing element of the apparatus, then into the annular space in them in very much the same manner as in the ingoing element. The superheated steam then passes through the outlet chamber to the side of the header, which is connected to the steam main.

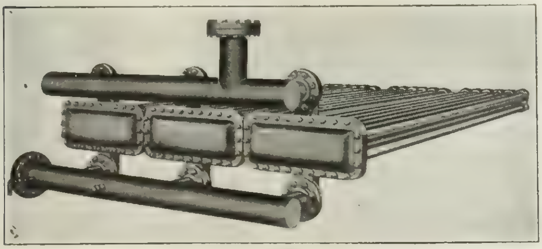


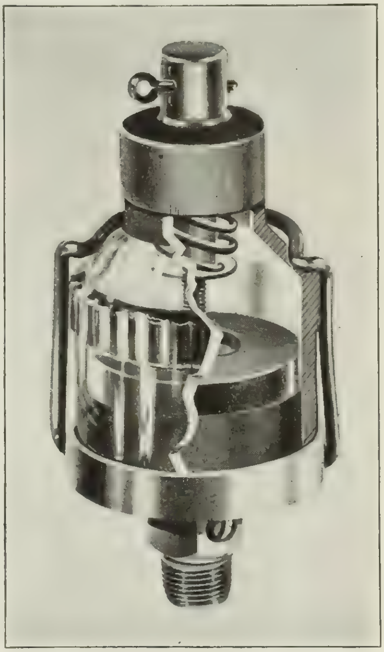
FIG. 2. ASSEMBLED SUPERHEATER

The headers are made of steel castings, and the tubes, of seamless drawn steel, are rolled into the headers the same as is done in boiler construction. The core pipes, which are contained within the tube, can be built in sections where it is desirable to remove them in restricted space, the sections being connected by joints made of steel tubing.

This superheater can be installed in various types of water-tube boilers and can also be used with return-tubular boilers.

New Standard Grease Cup

A grease cup known as the New Standard is made by the New Standard **Manufacturing Co.,** 1325 Arch Street, Philadelphia, Penn. The body of the cup is of glass and the base is of brass. In the shank is a screw for regulating the feed of the grease. A cap fits over the top of the glass body and is held in position by a double-lock bail, as shown in the illustration. In the top of the cap are three holes in which a cotter pin fits which also passes through a hole in the end of a spring spindle. This spindle is tapped for the threaded stem of the plunger, which forces the grease out through the bottom of the cup. The three holes in the cap permit of obtaining three tensions on the spring which exerts force against the plunger.

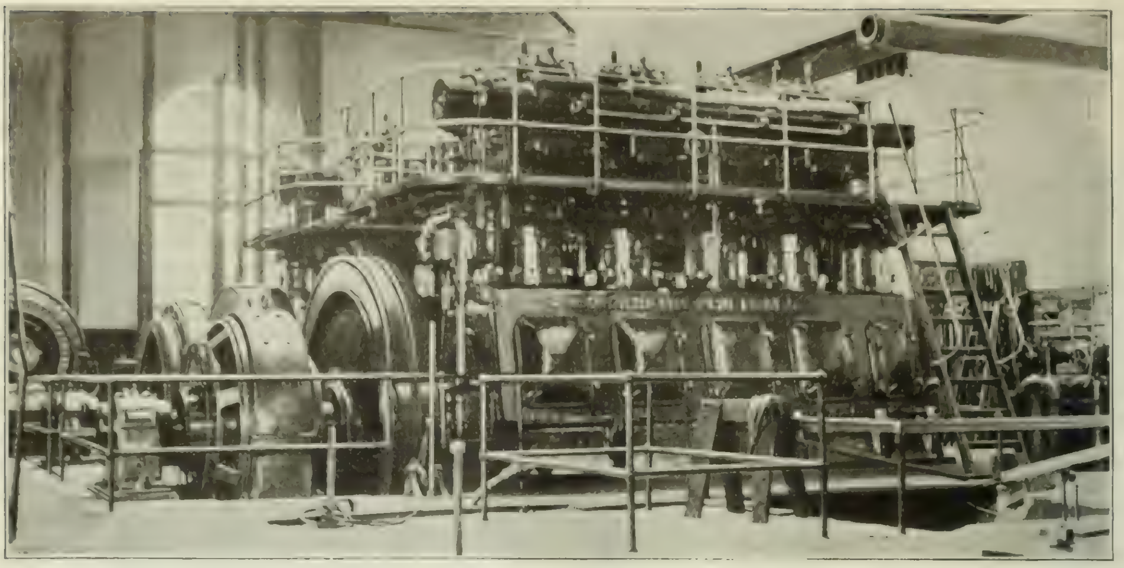


DETAIL OF STANDARD GREASE CUP

At the top of the glass body is a projection made to represent the color of grease, which is exposed to view when the grease in the cup is under the tension of the spring. As the grease feeds out, this signal gradually disappears as the cap covers it, and when it is no longer visible it indicates that it is necessary to readjust the tension of the spring for another period of feeding. This is done by turning the adjusting cap in a clockwise direction.

The feeding of the grease is regulated by adjusting the cotter pin and also by reducing the grease discharged through the bottom of the glass by means of the regulating screw. With these adjustments the pressure against the grease remains uniform from start to finish and overcomes any difficulty due to a difference in the tensional spring between the beginning and finishing of the feeding period.

To fill the cup, the body is removed after unclamping the double-lock bail, and it is easily replaced when filled. The capacity of the cup is 3 oz., it is made with a ⅜-in. shank and weighs 11 ounces.



Diesel Engines Prove Economical

Three 350-kw. Diesel units have been in service in this plant for more than two years in combination with steam equipment. Although maintenance cost is high a considerable saving has been realized during the war period.

THE following results were obtained in the plant of a traction company in the Middle West operating about 70 miles of electric railway lines together with an extensive lighting, power and steam-heating business, and serving a city of more than 60,000 population, with various suburbs in addition.

In addition to the local lighting business the company supplies lighting service to from 10,000 to 12,000 suburbanites, the farthest point reached being about 6 miles from the power plant. In every suburban community the energy is sold to the municipality, which resells it to the consumer. The lighting and power peak falls between 7:30 and 9 p.m. in the summer, and 6 and 8 p.m. in the winter.

The company operates about two miles of steam heating mains, a 16-in. main from the station reaching practically all of the downtown retail district and serving theaters, churches, department stores, etc. Practically all of the steam is low-pressure exhaust from the Corliss engines. Steam from the bleeder-type turbine and live steam are seldom needed. Typical load curves for the years 1917, 1918 and 1919 are herewith reproduced. The operating power-station equipment in 1915 included one 750-kw. Curtis turbine, one 500-kw. Allis-Chalmers Corliss engine, one 325-kw. Murray Corliss engine, one 1500-kw. Curtis turbine and one 500-kw. Allis-Chalmers turbine. There was also one 200-kw. high-speed Harrisburg engine not in use. The boiler-room equipment included six B. & W. 250-hp. boilers equipped with Jones underfeed stokers, two Stirling 450-hp. boilers with Jones underfeed stokers, one Stirling 150-hp. boiler equipped with blowers and two Edge Moor 500-hp. boilers equipped with Green chain grates.

In 1916 the lighting demand increased considerably and the demand for steam heat increased more than 20 per cent. The boiler room had reached the limit of its output and it became necessary either to increase its capacity or to obtain energy from some other source. A study of the Diesel engine led to the conclusion that the necessary increase in plant capacity could be obtained without increasing the boiler-room capacity by adding engines of this type, with an increase in efficiency of the plant as a whole.

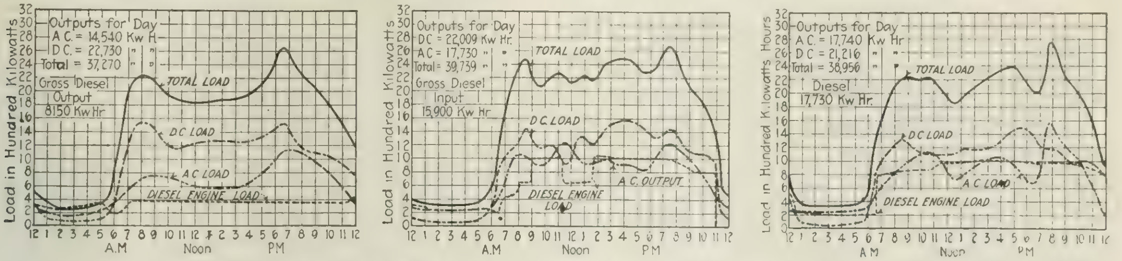
Two Busch-Sulzer four-cylinder, vertical, type-B, 500-hp., 200-r.p.m. Diesel engines were, therefore, installed in August, 1916. One is direct-connected to a 350-kw. 2300-volt. 60-cycle three-phase alternating-current generator and the other to a 350-kw. 550/575-volt direct-current generator. The guarantees for these engines provide that with a net load of from 500 b.hp. to 250 b.hp. the fuel-oil consumption will not exceed 6 gal. per 100 b.hp.-hr. to 7.4 gal. per 100 b.hp.-hr. for the two loads mentioned, respectively; the fuel oil to have a heat value of not less than 18,500 B.t.u. per pound, specific gravity at 60 deg. F. not higher than 20 deg. Baumé and not lower than 40 deg., with residue not more than 10 per cent. The speed variation from no load to full rated capacity is not to exceed 2½ per cent. from mean.

When the Diesel engines were installed, the 1500-kw. mixed-pressure turbine, using low-pressure steam from the Corliss engines and high-pressure live steam when necessary, was sold because uneconomical, and a 1500-kw. 3600-r.p.m. 2300-volt General Electric bleeder-type turbine was installed on the same foundation.

In November, 1917, one McIntosh & Seymour four-cylinder, vertical-type, 500-hp., 164-r.p.m. Diesel engine was installed. This is direct-connected to a 350-kw., 550/575-volt direct-current generator. The maker guarantees that this engine, when carrying between full and one-quarter net load will consume fuel oil of a heat value of not less than 18,500 effective B.t.u. per pound, not to exceed a range between 0.408 lb. and

0.628 lb. per brake-horsepower per hour. The speed variation is guaranteed not to exceed 3 per cent. from mean for normal variations in load, and the consumption of lubricating oil is not to exceed 2½ gal. per day.

With the installation of the McIntosh & Seymour engine the Harrisburg engine was removed, unit No. 2, a 500-kw. motor-generator set, was moved into line with unit No. 1 and a new 500-kw. motor-generator set was installed in line with these two. A 50-kw. motor-driven G.E. exciter set was also installed. This has sufficient capacity to serve the entire plant.

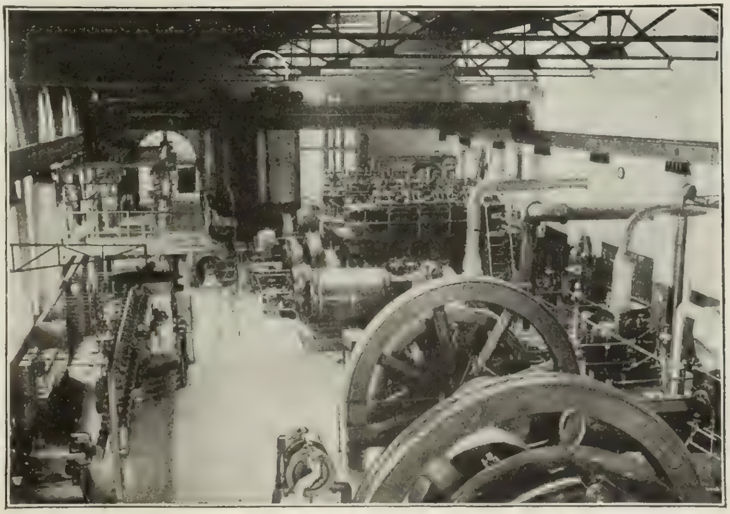


TYPICAL LOAD CURVES WITH DIESEL AND STEAM UNITS IN USE

The alternating-current Diesel-engine unit operates in parallel with the 1500-kw. turbine, and after midnight during the summer season when there is no heating it carries the load. The switchboard-panel for this unit is on the alternating-current switchboard located on the balcony. The direct-current "Diesels" operate in parallel with the direct-current steam engines and motor-generator sets. Their panels are on the direct-current switchboard on the main floor. The alternating-current "Diesel" frequently carries a railway load by conversion through a motor-generator set, but it was installed as an alternating-current unit so that it could carry the lighting load after midnight.

The fuel oil is delivered in tank cars on a spur track and unloaded by gravity to two underground steel drum storage tanks with a capacity of 12,000 gal. each. From the tanks it is pumped by small motor-driven pumps, supplemented with an auxiliary hand pump for emergency use, through Worthington piston-type oil meters to auxiliary supply tanks of 30 gal. capacity and located on the wall, about 6 ft. above the fuel-oil pumps. Fuel pumps on the engines draw the oil from the auxiliary tanks and feed it, according to the position of the governor, through discharge lines to the needle valves.

Another important feature is the cooling water for the engine. This is pumped from wells just outside the plant to a 16 x 16-ft. tank located on the roof of the plant. The pumps are of the vertical centrifugal type, direct-connected to motors and located in the wells close to the water level. From the supply tanks the water passes by gravity to the jacket on the engine cylinders, exhaust valves and air compressors and drains to a tank in the basement of the engine room. Thence by means of a small, horizontal, motor-driven pump, approximately 100 gal. per minute is carried back to the supply tank on the roof. This return of part of the cooling water to the original supply is a feature added some time after the installation of the engine. The temperature of the well water is from 50 to 55 deg. F. It was at first found that this was so low as to cause sweating in the air compressors owing to the fact that the air drawn in from the room is at approximately 72 deg. F. and is moist from the steam-generating equipment. Water formed in the air compressors drained out and washed out some lubricating oil. The 100 gal. of water per minute now returning from the basement at a temperature of about 110 to 125 deg. F., mixes with the cold well water and gives a resultant temperature of 70 to 80 deg., approximately the room temperature. The air intake has now been placed outside the building and all entering air passes through flannel strainers, thus eliminating all dirt and furnishing air not laden with moisture from the steam equipment.



GENERAL VIEW OF ENGINE ROOM

The water from the company wells is very salty. It cannot be used for piston cooling on the Busch-Sulzer engines because when heated the water forms a scale which destroys the efficiency of the cooling operation. City water is used for this purpose and is regulated to 38 lb. pressure. The water purchased from the city also contains scale-forming materials and if raised to a temperature sufficiently high will in cooling deposit a scale which requires an occasional sulphuric-acid bath to remove. Failure to remove this scale is liable to result in cracked pistons, and failure to remove the scale from the cooling passages in the cylinder heads will cause these to crack due to the fact that the cooling is not properly performed if the passages are filled with scale.

The accompanying table gives data on the operation of the plant for the years 1915 to 1918 inclusive.

OUTPUT AND COSTS OF OPERATION OF POWER PLANT

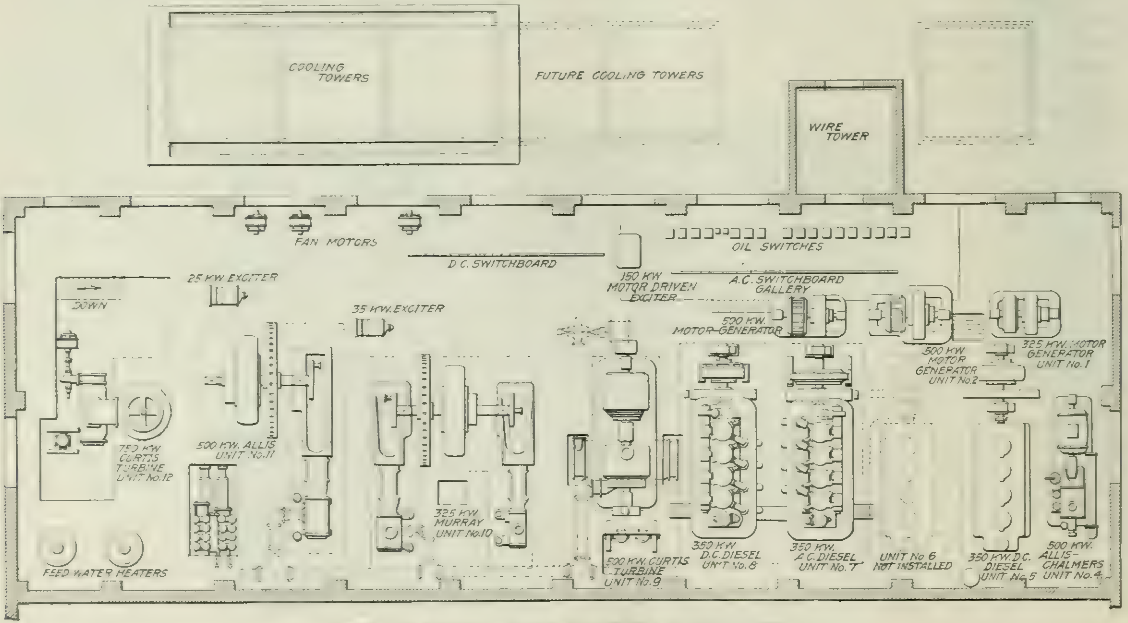
	1915	1916	1917	1918
Kilowatt-hours generated	10,776,910	11,531,890	12,613,994	12,907,625
Kilowatt-hours used by railway	6,161,741	6,194,657	6,180,776	6,076,431
Kilowatt-hours used for light and power	4,615,169	5,337,233	6,433,218	6,831,194
Pounds of steam sold	68,588,000	83,499,000	92,728,700	75,643,000
Kilowatt-hours generated by steam	10,776,910	10,062,180	8,309,057	8,291,539
Tons of coal used	38,411.51	42,652.19	35,736.17	31,110.43
Average cost per ton	$2.87	$3.50	$4.59	$4.96
Pounds of coal per kilowatt-hour	7.13	8.48	8.60	7.50
Cost of coal per kilowatt-hour cents	1.02	1.48	1.97	1.86
Total cost of coal	$110,339.57	$149,271.05	$163,938.99	$154,329.60
Kilowatt-hours generated by Diesel engines	None	1,469,710	4,242,377	4,616,086
Gallons fuel oil used	None	136,664	395,568	427,967
Average cost per gallon of oil, cents	None	3.14	3.70	5.66
Kilowatt-hours generated per gallon of oil	None	10.70	10.70	10.70
Cost of oil per kilowatt-hour, cents	None	0.292	0.345	0.566
Total cost of fuel oil	None	$4,294.12	$14,646.77	$24,238.99
Total fuel cost (oil and coal)	$110,339.57	$153,565.17	$178,585.76	$178,568.59
Average cost of fuel per kilowatt-hour, cents	1.02	1.33	1.41	1.38
Wages of power-station employees	$20,967.92	$24,797.08	$27,029.13	$39,320.33
Cost of water	7,839.49	9,699.51	7,424.19	8,711.05
Cost of lubrication	1,127.08	2,404.24	3,851.77	4,991.90
Cost of power purchased	317.26	386.32	1,898.75	
Miscellaneous expense	1,902.42	2,134.75	2,761.34	3,548.71
Power-plant maintenance cost	13,136.66	11,891.43	20,179.56	25,376.53
Total cost of power-station operation	155,630.40	204,878.50	241,730.50	260,517.11
Switchboard cost per kilowatt-hour, cents	1.44	1.78	1.91	2.02

It will be noted that during 1917 and 1918 the Diesel engines carried more than one-third the load of the plant. Also that the cost of coal per kilowatt-hour generated in 1918 was 1.86 cents, while the cost of oil per kilowatt-hour generated was only 0.566 cent. Part of this difference is offset by the increased cost of maintenance of the Diesel engines as compared with the steam units and by the fact that the coal cost also includes that of the coal used for heating, but there is an estimated saving of at least 0.9 cent per kilowatt-hour on all energy generated by the Diesel units. As this amounted to 4,616,086 kw.-hr., the saving was more than $41,000 in one year on switchboard cost.

VIRTUES AND LIMITATIONS OF THE DIESEL ENGINE

The Diesel engine is economical because it will burn a low grade of fuel and upon combustion of the oil, as in the gasoline engine, practically all of the mechanical energy is imparted directly to the piston. The maintenance cost, however, is high. This is still an unknown quantity in this particular plant as records are not kept which permit separating the labor and overhead costs from those of the steam equipment. Since the Busch-Sulzer engine is designed for piston cooling, the local condition of the cooling water has made the lubrication cost of this engine higher than on the other type. Recently, the Busch-Sulzer company has perfected the design of the piston-cooling equipment so that it does not interfere at all with the lubrication of the engines, and the lubrication has been reduced to as little as two gallons of oil per day per engine.

The ideal operating condition for the Diesel engine is a constant load. This is true not only because the engine operates at highest efficiency under a constant full load, but because the capital tied up in this equipment is so large that no units can afford to stand idle many hours of the day. As a Diesel engine cannot be heavily overloaded to carry a peak and as it is not economical to allow an engine to lie idle or operate on extremely light load many hours of the day, the advisable plan for a plant with a load having one or more extreme peaks is either to operate with all steam equipment or enough Diesel equipment to handle the average load and a turbine to take the peak and overload. There is perhaps some objection to a mixed installation of this sort due to the fact that an engineer who can operate steam equipment satisfactorily cannot always operate a Diesel engine equally well. Therefore a specially trained man is advisable.



COOLING TOWERS
FUTURE COOLING TOWERS
WIRE TOWER
FAN MOTORS
OIL SWITCHES
D.C. SWITCHBOARD
150 KW MOTOR DRIVEN EXCITER
A.C. SWITCHBOARD GALLERY
25 KW EXCITER
DOWN
35 KW. EXCITER
500 KW. MOTOR-GENERATOR
500 KW MOTOR GENERATOR UNIT No.2
325 KW. MOTOR GENERATOR UNIT No.1
750 KW CURTIS TURBINE UNIT No.12
500 KW. ALLIS UNIT No.11
325 KW MURRAY UNIT No.10
FEED WATER HEATERS
500 KW. CURTIS TURBINE UNIT No.9
350 KW D.C. DIESEL UNIT No.8
350 KW. A.C. DIESEL UNIT No.7
UNIT No 6 NOT INSTALLED
350 KW. D.C. DIESEL UNIT No.5
500 KW. ALLIS-CHALMERS UNIT No.4

PLAN OF ENGINE ROOM SHOWING MIXED UNITS

EDITORIALS

The Meter Expert

THE trend in power-plant design and management during the last four or five years has been in the direction of the perfection and use of appliances for metering and recording the performance of the plant, as well as the service rendered by the various integral parts, such as boiler-efficiency meters, steam-flow meters, water meters, coal weighers, CO_2 recorders, flue-gas analysis apparatus, tachometers, calorimeters and indicators.

The checking more closely of power costs and load conditions and the constant increase in appreciation of the economic possibilities of installing meters and recorders for this purpose in many cases so greatly increases the detail work imposed upon the operating force that satisfactory service in both operating and checking costs and efficiencies cannot be obtained; and usually, the tendency of the force is to keep the plant running and to neglect the finer points involved in taking meter readings, seeing that meters and recorders are kept in continuous service, etc.

All of which leads to the desirability of providing in most plants of any magnitude a special attendant for taking care of the meters, looking after their proper operation, taking records from them, and digesting and making use of this information in such a way that it can be applied to improve the efficiency and economy of the whole plant.

The extremely delicate design embodied in many recording instruments for the purpose of insuring high accuracy, and the highly technical knowledge required in the proper checking and intelligent use of present-day refined meter apparatus also rightly take this class of apparatus beyond the scope of the average plant operator, and again point to the desirability of a special man for meter service. Every maker of recording and metering equipment will impress on the prospective purchaser the fact that in order to furnish complete satisfaction the apparatus must be given intelligent and careful attention and should be in continuous service; that the records produced should be studied and digested and conclusions reached which can be applied to bettering plant operation. The man in charge of keeping the boilers, engines, turbines, pumps and multitudinous other equipment and details going in the power plant cannot logically be expected to give this continual and special attention, even though he is perfectly sincere in his attempt to do so.

It is also appreciated by most managers that the value of a meter of any kind is practically nil if it is not kept "up to scratch" all the time. With the delicate construction involved in most equipment of this nature, this means constant inspection, cleaning, careful adjustment and checking from time to time—all work that cannot be done properly and completely by the general operating staff in conjunction with their other duties.

In the manufacturing plant of today the production force is not called upon to take care of the accounting, but this detail work is intrusted to other hands, which have the time and special training for this work. The same thing should be true of the power-manufacturing station. All the evidence seems to point to an increasing appreciation of the value of a meter expert and accountant for every good-sized station.

The Personal Element in Arc Welding

IN THESE days, when one hears of welding ships' boilers, steam lines, pressure tanks, etc., electrically instead of riveting them, it is well to consider the element in the process upon which its success hinges; namely, the welder. Machine welding may eventually eliminate many of the factors that are contended with today and thus produce a weld of uniform excellence. Even then, much of the work will have to be intrusted to the individual, and it will be upon his experience and capability that the safety of the structure will largely depend, until such times as there may be developed a means of testing the weld without destroying it.

The training of such operators therefore appears to be a matter of vital concern to the interests involved. Certainly, the agencies that control the construction and insurance of ships, boilers, pressure tanks and the like, will insist on rigid qualifications as regards not only the process and the material employed but, more particularly, the demonstrated ability of the man who actually does the welding. And this is as it should be, for at the present time it is impossible to judge of the soundness of a weld from exterior appearances; the only person acquainted with the quality of the interior of the weld is the man who made it. Since so much may depend upon its reliability, it is essential that the operator be one who not only is capable of executing satisfactory work, but will recognize the presence of any element likely to jeopardize the success of a weld, and, moreover, one who will have the moral courage to advise his superiors of any possible flaw, be it due to his own neglect or not.

From what ranks of labor to recruit a competent force of welders is a serious question. Certainly, it would appear that the individual must be possessed of intelligence and integrity. The oxyacetylene welding industry has broken in men from many trades. Some of the most promising material has proved the most disappointing, and vice versa. To judge of a man's ability, he must be given an opportunity of developing himself, and it is consequently to the interests of the employer to provide the opportunity. As a matter of fact, it would be desirable to see the establishment of schools or shops of instruction, through the support of the industry in general, the purpose of which would be the training of certified operators to be employed on work of exacting specifications. There is much welding that does not require a high degree of skill, and it would not be necessary to insist upon the same qualifications for this secondary work as for the major operations.

The newly organized American Welding Society might well include among its contemplated activities the creation of an educational establishment of some kind that will provide means for education along the lines suggested. To it should be attracted a large group of clever, conscientious workers, as they would be a great factor in the looked for rapid development of welding, as applied to critical structures. But when this is all done, there still remains the fact that the human element is not infallible, and until we can test the weld without destroying it, there will always remain the possibility of a weld being improperly made in a structure whose failure will cause a catastrophe. We shall probably soon advance to the stage at which the electrically welded boiler will become a reality, but who would care to live with one of them unless he knew beyond a doubt that each seam was a one hundred per cent. weld?

Why Not Overhaul Now?

TO DATE one million troops have returned from France, and according to Secretary Baker the remainder are to return at the rate of three hundred thousand per month.

Finding employment for these men is a matter of pressing moment. Through lack of funds the Department of Labor has been unable to cope with the situation, and the War Department has found it necessary to establish agencies of its own.

Doubtless many of the men are returning to their former positions. Others have returned to find their old jobs no longer in existence. Some will be affected by the wider employment of women; while others, profiting by their experience in the Army, are aspiring to better positions than they formerly held.

Unemployment, however, does not appear general throughout the country; instead, it is localized in certain large cities and industrial centers, particularly those near ports of debarkation—a condition easily explained. Men from the rural districts naturally desire, after being demobilized, to locate in the large cities. Others without such intention linger in these cities to see the attractions, spend their money and are compelled to seek employment.

This excess of labor is but a transient condition. As soon as industry has become readjusted to peace-time conditions and started full speed ahead, of which there are promising indications, it is anticipated that there will be an actual shortage of labor, especially in view of the increasing emigration rate.

Meantime there is plenty to be done.

During the war equipment of all kinds was overworked and taxed to the limit of its material endurance. The exigencies did not permit taking out of service for overhauling, and much of it did not receive even ordinary maintenance. This condition was aggravated in some cases by inexperienced operatives.

Today we are witnessing the result; machinery everywhere is creaking, engines are pounding, furnaces need relining, joints are leaking, ferryboats are unable to maintain their schedules, roadbeds need attention, buildings are in need of repair—in short, the country physically needs overhauling to put it in condition for the stress of normal industrial conditions.

To do this requires labor. The labor is now available; in a few months it may not be. The proposition is neither one of patriotism, nor one of appreciation for the work done "over there"; it is just simple economy to put the house in order.

The Need of Boiler Inspection

AN IMPRESSIVE demonstration for those who assume that ordinary business caution and self-interest are sufficient inducements for the owners and operators of boilers to keep them in a safe if not an efficient condition is furnished by the Annual Report of the Inspection Department of the Hartford Steam Boiler Inspection and Insurance Company. During the last year their inspectors examined 391,674 boilers, in which they found 194,849 defects sufficiently serious to be reported, or nearly one-half as many defects as there were boilers. Of these defects 21,847, or over eighteen per cent., were positively dangerous.

The inspector is ordinarily concerned with defects that impair the safety of the boiler, and in ordinary years will report about one thousand settings as defective, of which perhaps eight hundred will be reported as dangerous. During the last year the inspectors have been working in connection with the various committees of the Fuel Administration, and have striven for efficiency as well as for safety, reporting 9890 settings as defective, or nearly ten times as many as usual, while those regarded as dangerous numbered 828. The effect of the continual vigilance of a corps of inspectors of this kind upon the list of industrial accidents is well worthy of consideration.

One of the weak points in the early types of squirrel-cage induction motors was the connection between the rotor bars and short-circuiting rings. This connection was generally made by bolting or soldering the bars to the rings. For a number of years it has been common practice for electrical manufacturers to weld the bars to the end rings or cast the rings onto the ends of the bars, and this practice has practically eliminated the trouble experienced with bolted or soldered connections. The latest practice is to cast the rotor winding on the core, the stripped rotor core serving as the mold in which the bars are cast.

Elsewhere in this issue is an article dealing with the lubrication of submerged pins in the governor mechanism of hydraulic turbines, which will be received with much interest by hydro-electric engineers. Corrosion of these pins imposes severe strains upon the mechanism and often causes the fluid pressure to be greatly increased, perhaps dangerously increased, at a time of heavy load demands—a critical time. The monel-metal pin by trial shows itself, with direct lubrication, to be by far superior to all others.

Oil and water do not mix, according to an old saying; but it will be difficult to impress that fact on the oil producer who has to spend considerable money in dehydrating petroleum before he can market it.

"Emancipation of the toiler" is a phrase with a pleasing sound; but if it is interpreted as freedom from the necessity of working, it is only a thin disguise for Bolshevism.

The man who doesn't want to be convinced of a mistake follows closely a familiar rule of cylinder design: The thicker the head, the greater the resistance.

An untrained fireman somewhat resembles the average brick chimney. His footing is broad and stable, but he is rather thin at the top.

Correspondence

Meter Readings Showed Up Leak

Meters, if read daily and the readings watched, are an accurate index of plant conditions, especially if there happens to be much unexposed or underground piping; and if carried out properly, the readings are a check against undue waste and hidden leaks as applying particularly to water or gas lines.

The daily readings should be recorded and filed for reference, as they will be found useful for comparison and they offer a ready means of supplying such data as the manager may ask for at any time. I had occasion recently to realize what an important matter this is, and if I had not made daily meter readings, I do not know how long a serious leak would have remained undiscovered.

On reading the cold-water meter one morning, I found that three times the usual amount was recorded; as no leaks were reported I thought that perhaps the meter had given a false reading. But on finding a like reading the next morning, I decided that there must be a blind leak somewhere that did not show up in the usual way, and so set out to make a thorough search for it. The only evidence discovered was a small amount of vapor rising from the conductor pipe leading from the roof of one of the residence houses to the underdrainage system.

There was a 20-in. conduit carrying steam, return, hot water and circulating lines from the main building to this house, and as this conduit was drained into this same underdrain, it seemed reasonable that the leak might be in one of these pipes and followed the conduit into the underdrain and so on into the conductor to the roof. This proved to be the case, for after shutting off the hot-water line the leak stopped.

This line was 1½-in. lead-lined galvanized pipe, and to replace it not only meant digging out the line and opening the conduit for a distance of 175 ft. and replacing, but for half the distance we would have to go right through a fine flower garden and dig up shrubbery, etc., so I was asked to try some other means of renewing the line.

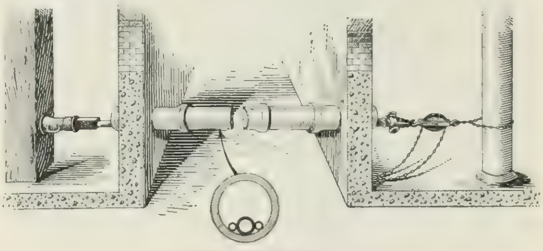
On referring to the blueprints it was found that this line ran straight with no offsets between the two buildings, and it looked as though it might be possible to pull the old line through the conduit and drag the new line through on the end of the old one. It seemed worth trying, as the only danger of trouble seemed to be in pulling the old line in two at a weak spot, but even so it would not make matters worse than they were.

After breaking the connections at both ends of the line in the basements of both buildings, a two-ton chain hoist was rigged on one end and a screw-jack was placed against the other end. The jack was used to keep sufficient pressure against the line to supplement the pull on the hoist, which might be great enough to pull the line apart. With one man on the hoist and another on the jack and both working by signal (rapping on the pipe), a start was made. The first foot came hard, but the next came easier, and after the first eight feet was through it was found that the hoist alone was sufficient to do the work.

A length of new brass pipe was then connected to the tail end and pulled in, and the length of old pipe in the other basement was disconnected and so on; connecting a new length on one end and pulling it in and disconnecting the length of old pipe on the other end, until the old line was all out and the new brass line was in and connected up. The whole job took only a little over a day to finish. This was about one-third the time necessary to just dig the trench; besides, mutilating the flower garden was avoided.

This line was covered with 85 per cent. magnesia pipe covering, and the new line was pulled through without pulling out more than a handful of this material, a little of which came through with each coupling.

The lead-lined pipe was found to be eaten through from the outside in several places, which goes to show that brass pipe only should be used to carry hot water, especially in unexposed places where not easily replaced.



REMOVING THE PIPE FROM THE CONDUIT

We have hundreds of feet of lead-lined pipe carrying hot water to different buildings, and our experience has been that where it is exposed, as in our open tunnels, with only magnesia covering, it has given no trouble after being installed for five years; but where it was run through a tile conduit buried in the ground, we have had to take it out and replace with brass, and in each case the lead-lined pipe was found to have been eaten through from the outside.

The second time this happened a piece of the pipe and covering and tile conduit were sent to a laboratory for analysis in order to determine what caused the eating away of the pipe, but we received no satisfactory answer. Perhaps other engineers have had similar experience, and it might be interesting to know about it.

Records such as meter readings are easily secured with but little trouble, and they should be kept on file. If they are studied, they will tell a great deal about the conditions in the plant. I had occasion lately, in connection with the Fuel Administration work, to examine many questionnaires, and it was surprising how many engineers could not answer the question as to how much electric current was purchased and how much was generated in their plants, although there were meters there which should have given them this information.

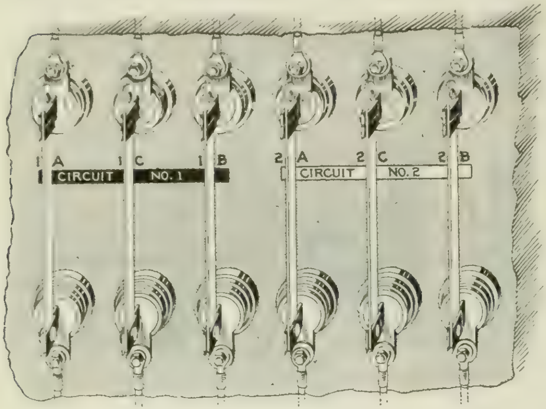
Windsor, Conn. J. A. Lane.

Installing Disconnecting Switches

There are often several ways of doing a job. Each of these ways may be good, but only one method can be the best. The way in which D. R. Hibbs overcame the difficulty in installing disconnecting switches, as described on page 293 of *Power*, is open to criticism.

Instead of turning the disconnects of each circuit around alternately so that each circuit would be distinguishable from its neighbors, it would have been simpler and more satisfactory in the ordinary way to have identified each circuit by stenciling. Moreover, each phase of each circuit should also be stenciled.

Without the installation of barriers between the respective circuits, each circuit could be segregated from those adjoining it, so far as preventing mistakes on the part of the persons manipulating them is concerned, by merely painting on the marble mounting a line about two inches wide extending across the space covered by all three phases of one circuit. White and blue or white and red can be used alternately, or the lines of alternate circuits can be staggered so as to distinctly indicate the change from one circuit to the next. All phases should be marked, as also the circuits, because many mistakes occur when disconnects are hurriedly opened under load. A suggested form of marking that is safe and simple is shown in the figure.



MARKING DISCONNECTING SWITCHES

As to barriers between circuits and phases, the war has taught that massive barriers so often previously employed are not needed in many cases. For potentials below 4000 volts and with a minimum spacing of 10 in. barriers can be dispensed with altogether, except perhaps the generator disconnects, where the concentration of energy may make them advisable. Barriers are installed not only to prevent short-circuits due the bridging of conductors by arcs, but to prevent confusion. The methods herein advocated eliminate the latter. There is one instance where barriers are always advisable, or else additional spacing should be allowed, and that is where intense drafts or winds may be expected to blow across the various conductors. Barriers in these cases prevent an arc being blown across phases or circuits and causing a short-circuit.

There is one further criticism that might be offered. Where disconnecting switches are installed in the horizontal position with the switch blade facing downward (as in the illustration) and where the switch is installed in the vertical, it is usually a wise precaution to use a type of disconnecting switch equipped with a locking device where the possible energy transmitted through the switch is 200 kw. or 100 amps. or more. Disconnects sometimes open under the powerful influence of electromagnetic forces accompanying heavy current rushes, as the short-circuiting of a generator, etc. The locked type of switch cannot do this.

With the arrangement of disconnects shown by Mr. Hibbs—that is, the horizontal with the switch blade facing downward, or closing upward—the switch blade is kept closed only by the friction between the blade and the clips and hinge of the switch. Poor contact between these, and a heavy blade, may result in the latter falling open after considerable time in service. Heavy currents, beyond the rating of the switch, may cause partial annealing of the clips, in which case the friction between the clips and the blade will decrease, possibly allowing the blade to fall open. This fact is also an argument in favor of the locked type of switch.

Chicago, Ill. W. H. DeMuth.

Better Cylinder-Oil Testing Methods

Wilbert Walton Cranford on page 327 of the March 4 issue of *Power* says, "The proper place to test a cylinder oil is in the cylinder of the engine," from which expression I would infer that Mr. Cranford would feel inclined to try any old oil on his best engine, although 1000 employees were dependent upon that engine for power. Certainly that would be imprudent and unbusinesslike as well.

As for utilizing a recording thermometer with two pens, as suggested, I should think such a plan would be a logical solution from a theoretical point of view. However, operating engineers know from years of experience that the valves invariably show distress first when the lubrication is faulty.

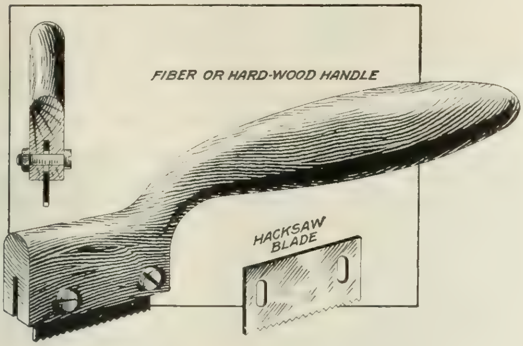
Should the absence of lubrication be so pronounced as to actually cause a rise in temperature of the cylinder walls, the result would be disastrous indeed, as the piston rings would likely seize, causing the whole cylinder to shiver or vibrate. The piston rings would tell the engineer about it a long time before the thermometer would. Furthermore, I believe it would be almost impossible to produce a higher temperature at the center of the stroke than at the heads, because the cylinder condensation would absorb the frictional heat as fast as generated. The fact of the matter is, if any difference in temperature were observed, the highest would be found at the heads, as the full boiler pressure exists at that point, and a much lower pressure would obtain at the center of the stroke, since it is customary to operate steam engines with cutoff at one-quarter to one-third stroke, allowing the steam to expand. The effect of compression must also be reckoned with, as it is customary to set the exhaust valves so as to produce a pressure equal to the normal steam pressure; very often it is higher.

Where superheated steam is used, the temperature is always higher at the heads, as evidenced by the pitting action upon the cast iron at these points of entrance. Mr. Crawford also speaks about cutting the oil down until the rise in temperature was perceptible. This would be analogous to cutting the lubricating oil down on the bearings until they showed signs of heating. Certainly, no practical engineer would be so foolish as to pull off such a stunt as that. Waldo Weaver.

Franklin, Ohio.

Commutator-Mica Cutting Tool

A handy tool for use in cutting down the mica between commutator segments of a motor or generator can be made by inserting a piece of hacksaw blade in a hardwood or fiber handle shaped as shown in the illustration. It can be made any size to fit the requirements. Two oblong holes are made through which bolts are passed in order to secure the hacksaw blade at any angle desired. W. W. PARKER.



COMMUTATOR MICA CUTTER

Guantanamo, Cuba.

Salvaging the Disabled

The editorial on page 371 of Mar. 11 isue under the caption, "Salvaging the Disabled," will appeal to the true American, I am sure, but I feel that the statement that "a partially disabled man can be trained to render efficient service as a switchboard operator, a pump runner or attendant of other auxiliaries" is a trifle misleading.

Years ago I was taught to hold one hand behind my back while working about the switchboard, and one day when I got a trifle careless and took a little dose of 600 volts, the chief remarked that the fools were not all dead but that one more came near being added to the list.

Today we expect our switchboard operators to use both hands and once in a while their feet. Less than half an hour ago I saw a switchboard operator barely save the load by mighty quick head and hand work when one machine kicked out.

I am not trying to get away from the fact that these men have fought and bled for a heroic cause, but one little false move of a partially disabled man in a power house might stall the wheels and deprive hundreds or thousands of work. Is it good business to ask a manufacturer to take on as a pump runner a man who is so crippled that he cannot properly look after the apparatus and when one false step would put the water for boilers or condensers out of the running? Is it not better that the profits of the business pay this man's living rather than take a chance?

It is true that "in the boiler room, with its stokers and modern appliances, special training and intelligence has replaced the requirements of brawn as of former days" to a degree, but I have seen more genuine "beef" used around a stoker plant than I ever saw used in a hand-fired plant. I am conversant with boiler plants from 5000 to 40,000 hp., and I can place only one in which the stoker superintendent holds a position that requires no manual labor of any kind.

My plant generates several thousand boiler horsepower, but the fireman on the shift is required to operate the stokers, maintain the proper draft to handle the load and supervise the coal handling inside the boiler-room walls, and at times he actually cleans fires. This work requires him to go from basement to bunker, a distance of forty feet or more, in quick step at times. Would you have a partially crippled man do this work? The man went to war, gave all that was asked and now that he is home must he work in a power plant, thinking that the work does not require a man with all of man's power?

Why lead people to believe that the power plant can use men who are partially disabled, when we who work there every day know that it requires all the energy of able-bodied men to produce the best results and even then we fall short at times? Why not let these men take positions of minor importance, and if the remuneration is not sufficient let those of us who were fortunate enough to be left at home be taxed to help support those that did go, but let us not, under the guise of helping these poor fellow men, place the heart of the factory, mill or shop in jeopardy. C. W. PETERS.

New York City.

Removing a Broken Through Stay

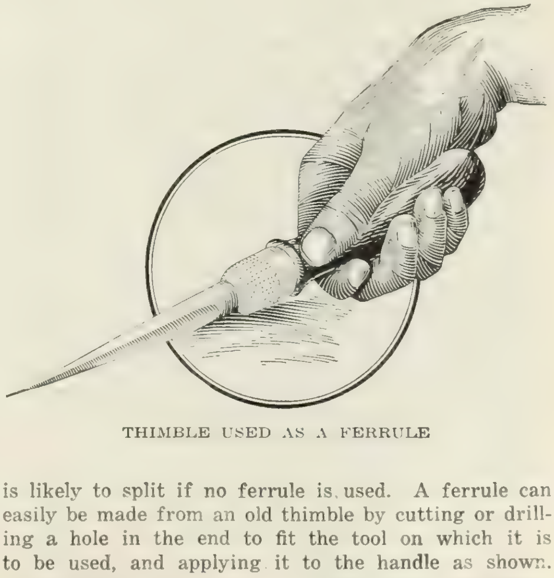
I had an unusual experience recently. One head-to-head stay broke off at the thread at the back end in one of our 16-ft. x 66-in. return-tubular boilers. The job was to get the inside nut off and the stay out as there was not room enough to take the other nut off and cut the stay off in front of the distance piece.

I had a long chisel made to go down between the tubes so as to split the nut. H. R. JOHNSTON.

Vegreville, Alta., Canada.

Easily Made Ferrule

Sometimes a ferrule may be lost from a tool handle or one is needed to put on a home-made handle which is likely to split if no ferrule is used. A ferrule can easily be made from an old thimble by cutting or drilling a hole in the end to fit the tool on which it is to be used, and applying it to the handle as shown.



THIMBLE USED AS A FERRULE

Norristown, Penn. WILLIAM H. WATSON.

Leaks and Wastes in State Institutions*

By F. J. McCULLOUGH

EACH pound of coal burned or each gallon of water allowed to reach the sewer without having accomplished a useful purpose might be called a leak or a waste. From the practical operating standpoint, however, it is necessary to draw a sharp distinction between a leak or waste that costs more to stop than to let it continue, and a leak that costs less to stop than to let it continue. The chief engineer must know what leaks and wastes exist, what they represent in dollars and cents and what it will cost to stop them. The leaks and wastes in an institution are a better indication of an engineer's ability than a civil-service examination.

Leaks and wastes may be classified under the following heads: Wastes of coal, heat, steam, electric current and water, and loss from damage to equipment. Waste of coal and heat in the boiler room was covered in previous papers. To give some idea of the loss of heat from uncovered pipes the following example may serve: Take a high-pressure uncovered pipe 6 in. diameter and 100 ft. long, carrying steam at 125 lb. pressure and located in a room where there are no drafts and the temperature is 70 degrees. Under these conditions each square foot of surface will give off 3.2 B.t.u. for each degree difference of temperature between the steam and the surrounding air. Steam at 125 lb. gage pressure has a temperature of 353 deg., and with air at 70 deg. the difference is 283 deg., so that each square foot of surface will give off 283 × 3.2 = 905 B.t.u. per hour. The 6-in. pipe 100 ft. long has 173 sq.ft. of surface, so that the loss each hour is 157,000 B.t.u. Assuming a boiler efficiency of 60 per cent. and coal at $3.50 per ton in the bin, with a heat value of 11,000 B.t.u. per pound, every cent's worth of coal burned puts 37,000 B.t.u. into the steam header. An hourly loss from the pipe of 157,000 B.t.u. means a waste in coal of 4¼c. per hour, $1.02 per day, or $372 per year. With the pipe covered, all this heat could not be saved, but standard-thickness 85 per cent. magnesia covering has shown an efficiency as high as 87 per cent., so that with steam continuously in the pipe the covering would effect a yearly saving approximating $324. At current prices the covering would cost about $1.15 per foot applied, so that in the saving of coal alone it would pay for itself in four months. The same pipe carrying 2-lb. steam pressure would waste enough heat to pay for 85 per cent. magnesia covering in less than a year.

FAN OR HOT-BLAST SYSTEMS IN STATE BUILDINGS

A number of the state buildings are heated by fan or hot-blast systems. The average condensation in the coils per square foot of surface per hour is 1.56 lb. when heating air from 30 to 105 deg., but in zero weather, heating air from 0 to 105 deg. will condense 2.26 lb. per hour, or an increase of 45 per cent. It is evident that when the building is being warmed up in the morning and has few or no occupants, all the outside air should be shut off, and the air in the building recirculated by proper damper arrangement. Modern ventilating systems are designed for delivering from 25 to 30 cu.ft. of air per minute for each occupant. This will maintain a standard of purity of the air which has arbitrarily been decided upon, but this amount of air can be reduced almost one-half before any perceptible effect is noticed on the occupants. Then, as the ventilating apparatus takes 45 per cent. more steam when the outside air is down to zero, there is no reason why the standard for purity of air cannot be reduced during this time by recirculating from one-third to one-half of the air, and taking the remainder from the outside.

From a study of temperature records of the various state institutions it is evident that one serious loss is due to overheated buildings. These records show many instances of temperatures of from 75 to 80 deg. Temperatures may be considerably lower if attention is given to the humidity, the moisture in the air. In summer the relative humidity in this climate is usually 60 to 70 per cent., and as the windows and doors are open it is the same indoors as outside. With this humidity a temperature of 65 to 68 deg. is comfortable. In winter the outside humidity is about the same, but as the air is heated its capacity for moisture increases, so that the relative humidity is much less. In a steam-heated room it is seldom over 25 per cent. and is frequently less.

The accompanying illustration is a reproduction of a chart prepared by the Chicago Commission on Ventilation, who made a test of the Chicago Normal School a few years ago. From the chart it can be seen readily that as the humidity increases the temperature for greatest comfort decreases, and vice versa. These experiments showed conclusively that with a relative humidity of 55 per cent. and a room temperature of 66 deg. the occupants were just as comfortable as with a humidity of 25 per cent. and a room temperature of 74 deg., as may be determined by extending the chart slightly at the left.

In the latitude of Chicago the average outside temperature during the heating season is 34 deg. To keep a room at 66 deg. it is necessary to maintain a difference between inside and outside temperatures of 32 deg. With a room temperature of 74 deg. the difference is 40 deg. The heat losses from a building by radiation or air changes is in direct proportion to the difference between inside and outside temperatures, so to maintain a temperature of 66 deg. inside means a relative heat loss of 32 and to maintain 74 deg. means a relative heat loss of 40, or an increase of 25 per cent. in the amount of heat required to maintain the higher room temperature. The saving of heat by carrying higher humidity and lower temperature will be somewhat less than the 25 per cent., because some steam will have to be introduced into the room to raise the humidity and only a small part of the total heat of this steam will be given up to raising the room temperature. The amount of steam admitted into the room to maintain the humidity will be small, as compared to that required to maintain the room temperature, however. A saving of, say, 15 per cent. of all the steam used for heating would be worth trying for.

VARIOUS CAUSES OF STEAM WASTE

Steam is often wasted through steam traps. Most of the traps in state institutions, other than radiator traps, are of the intermittent or continuous discharge types, which can be equipped with gage glasses, a glance at which in passing tells the story. If the glass is full of water, the condensate is not being removed fast enough; if it is empty, the trap in all probability is leaking steam. On this type of trap the water should remain near the center of the glass.

General kitchens frequently are equipped with steam roasters. If they are steam-jacketed and the discharge is trapped, they are not as wasteful as the type that is not jacketed. To the latter type steam is admitted through a ¼-in. pipe with numerous orifices to give an even distribution of the steam. The vent to the atmosphere is made about an inch in diameter, so no pressure can build up in the compartment. There is also a drip connection for the condensate, but in reality most of the steam delivered to this type of cooker blows right through and goes out the vent.

Some time ago the writer put a steam-flow meter on a battery of six of these cookers, some of which were four tiers high and the others three tiers, so that there were 22 compartments of the same size. With steam at 40-lb. pressure each compartment took 66 lb. of steam per hour. As the pressure was reduced, the consumption of steam decreased until at 5-lb. gage pressure each compartment only took 28 lb. per hour. This represented a saving of considerably over 50 per cent. and did not interfere with the operation of the cookers or the time required to cook the food. Even though the temperature of the steam at

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*Abstract of paper read at the first annual meeting of chief engineers of Illinois State Institutions, Dunning, February, 1919.

40-lb. pressure is 74 deg. higher than steam at atmospheric pressure, as soon as it expands in the cooker to atmospheric pressure it has a temperature of only 212 deg., the 1 or 2 per cent. of moisture that the steam carries preventing it from superheating at the point where it is throttled.

When there is an excess of exhaust, as in the summer months, the waste of steam from leaky engine valves, scored cylinders or worn cylinder rings and from the valves not being properly set is a direct loss. Steam is wasted also through leaky back-pressure valves, valve stems, defective gaskets at flanges and at the threads where they are not tight.

WASTE OF ELECTRIC CURRENT

In the winter time, when there is not enough exhaust for heating, the only real loss due to waste of current is the additional wear and tear on the machinery producing the current and the renewal of lamps, but during the summer months electric wastes are dead losses and should be prevented as far as possible. Motors should not be allowed to run when the machines they drive are not in use, and on alternating-current generators the voltage should be controlled as much as possible by the exciter rheostat instead of the generator rheostat. The exciter rheostat carries a small current, just enough to excite the fields of the exciter, but the generator rheostat carries all the current the exciter delivers, which is about twenty times that of the exciter rheostat. Hence it should be set with only a few points of resistance cut in, to be used in getting the fine adjustment of the generator voltage, and as much of the controlling as possible should be done with the exciter rheostat.

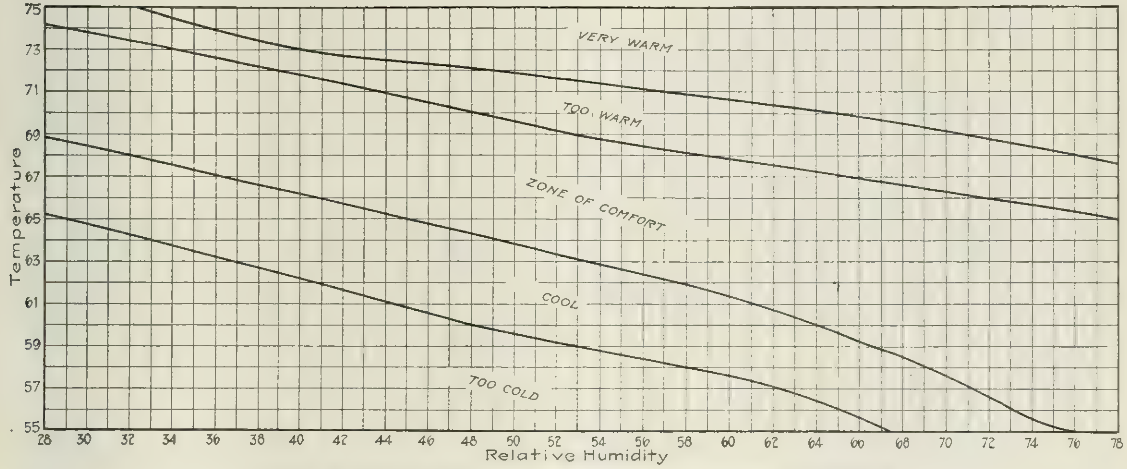

CHART SHOWING HUMIDITY INCREASE AND COMFORT DECREASE

Incandescent lamps are built for a life of approximately 1000 hours of burning. If they last much longer than that, it means the voltage on the line is too low and that the lamps are uneconomical because they are not up to candlepower and the wattage consumed is too great for the light they are giving. On the other hand, if their life falls short of 1000 hours, it means the voltage is too high and the lamps are uneconomical because of the cost of frequent renewals.

Where the condensing water from ammonia condensers is run to sewer, thermometers should be installed to give the temperature of the water at the inlet and the outlet from the condenser, so that the water may be throttled down to a point at which the rise in temperature over the condenser will not exceed ten degrees. Even where the water is used again, it costs money to repump it. If the condenser is above the vacuum pumps of the heating system, all the makeup required for the boiler plant should be taken from this source to save repumping. In fact, one of the best places to admit the make-up water, during the heating season, is just ahead of the vacuum pump.

There is a leakage of water from faucets and bad underground pipe. Self-closing faucets, when kept in order, make a material saving in water. Cast-iron pipe should be used for all underground work where possible, as it lasts longer than steel pipe.

Recently, one institution that had a high per capita water rate made a study of where the water was going by installing temporary meters on the different lines and taking readings throughout the twenty-four hours. The total water consumption was reduced a little over one-third, but the gain is gradually being lost, and today only one-sixth less water is being used than before the saving campaign. This shows how difficult it is to stop wastes and keep them stopped, even after it is known where they occur.

With hot water it should be pointed out that it is not only a waste of water but also a waste of heat in the water. Assume water to cost ten cents per thousand gallons, and that it is heated 80 deg., from 60 to 140 degrees. For one cent, 100 gal., or 834 lb., of water is purchased, and it requires one B.t.u. to heat one pound of water one degree. Hence into one cent's worth of water there go $834 \times 80 = 66{,}720$ B.t.u. Previously, it was shown that one cent's worth of coal put 37,000 B.t.u. into the steam, so that each cent's worth of water requires two cents' worth of coal to heat it. The wasting of one gallon of hot water is equivalent to wasting three gallons of cold water.

Hot water, of course, is wasted at faucets, just as the cold water, but with an additional waste where it is necessery to flow gallons in order to get warm water. In all hot-water lines circulation through the heater should be maintained with a pump so there will be no dead-ended lines in which the water can cool. There are leaky valve stems and threads, where the loss of heat or water may be insignificant, but which result in a loss from damage to the covering, pipes and floor. In the power house hot-water waste should be watched carefully, as here are the more important items of waste from traps and drips, which may be going to the sewer when they should be returned to the feed-water heater. Then there are leaky blowoff valves and the overflow from the feed-water heaters or the hot-water receiving tank. In order that the engineer may more readily see these losses, it is well to have only one direct connection to sewer from the power house, this being required for the boiler blowoffs. All other connections to sewer should be made, where possible, through open tell-tales.

One piece of equipment often abused is the steam pump. Boiler-feed pumps are generally set where accessible to the firemen, which generally means in the boiler room, where they are subjected to coal and ash dust. This results in damage to plungers and rods and with scored rods trouble in holding the packing. Where possible it is well to have the pumps in a small room or inclosure with plenty of glass in it, so that the operations of the pumps may be observed from the boiler room. Steam pumps are not built for high piston speeds, and in this respect the vacuum pumps are frequently abused. As the vacuum is impaired by leaky return lines or radiator traps, it is the tendency to speed up the pumps instead of looking for the real trouble.

Oftentimes the engineer thinks that the more vacuum he carries the better the heating system will work. Three or four inches of vacuum should be enough on any building, while often it is carried so high as to have a vacuum on the steam main even back to the oil separator in the power house. With this condition existing, cylinder oil will be carried over into the heating system, resulting in a great deal of radiator-trap trouble, which will extend back to the boilers.

A. I. E. E. Annual Convention

The American Institute of Electrical Engineers will hold its annual convention this year at Lake Placid Club, Adirondacks, N. Y., June 24-27. The principal features of the program, as announced in the May proceedings of the Institute, are: Tuesday morning, June 24, address by President Comfort A. Adams, and the presentation of two papers, "Present Day Practice of Transmission and Tie Line Relay Protection," by H. R. Woodrow, D. W. Roper, O. C. Traver and P. MacGahan and "Grounded Neutral," by H. R. Woodrow and William E. Richards. Tuesday evening, informal reception and dance. Wednesday noon, conference of Committee on Development, section delegates and A. I. E. E. officers at luncheon. Thursday morning, conference under the auspices of Committee on Development, including section delegates and Institute officers, open to all Institute members. Friday morning four papers will be presented: "High-Tension Single-Conductor Cables for Polyphase Systems," by W. F. Clark and G. B. Shanklin; "Electrostatic Field and Electric-Power Cables," by H. W. Fischer and R. W. Atkinson; "Commercial Problems of 220,000-Volt Power Transmission," by A. E. Silver; and "The Effects of Transient Voltage on Dielectrics—II," by F. W. Peek, Jr.

The committees have purposely left considerable time unassigned, as it is expected that the conferences under the auspices of the Committee on Development will be one of the most important features of this convention and will undoubtedly occupy considerably more time than the sessions that have been scheduled. It is also the aim of the committees to leave plenty of time for social and recreation features, including outdoor sports, to which the location at Lake Placid is especially adapted.

Engineering Courses Popular

One of the most popular divisions of education made available to disabled soldiers by the Federal Board for Vocational Education is that of engineering, in the various branches of which there are now 178 students, thus giving refutation to a somewhat prevalent idea that the vocational education available for disabled men is confined to manual trades. In this general classification, 6 men are taking architectural engineering; 2 chemical engineering; and 80 are preparing to be civil engineers. Electrical engineering takes 30; general engineering, 25; mechanical, 22; mining, 7; and steam, 8.

Indicating the character of institutions at which these men are pursuing their education, the following are being used: Harvard University, Massachusetts School of Technology, Franklin Union, Boston, Hawley School of Engineering, New Bedford Industrial School, Saunders Trade School, New York Electrical School, Mechanics Institute, Pratt Institute of Brooklyn, Rensselaer Polytechnic School, Columbia University, Heffly Institute, Lawrenceville Trade School, Carnegie Institute, Pennsylvania State College, Johns Hopkins University, Georgia School of Technology and Colorado State School of Mines.

Claude Graham-White, the English aviator, says regarding the proposed transatlantic flight: "Everything depends on the engine. If a machine breaks down, the wireless goes also, and then, no matter what the safety devices may be, the machine makes a very little speck on the enormous area of the Atlantic. If the feat is successful the public will applaud it, but if lives are lost there will be censure on account of the foolhardiness of the attempt."

Personals

R. L. Thomsen has been appointed sales manager by the Terry Steam Turbine Co., Hartford, Conn. Previous to this appointment Mr Thomsen was manager of the marine department for the Griscom-Russell Co.

W. W. Tarleton, who has been connected with the Southern Manganese Corp., of Anniston, Ala., for the last two years in the capacity of purchasing agent and traffic manager, has joined the sales department of the Anniston Steel Co., same city.

Miles Carey, of Welch, W. Va., who has been division manager of the Appalachian Power Co. for six years, has resigned that position to accept another with the Penn Public Service Co., of Pennsylvania, and will be located at Clearfield, Penn. B. P. Rouse, who has been connected with the company for some time past, succeeds Mr. Carey as manager.

R. W. Spofford has been appointed local general manager of the Manila Electric Railroad and Light Co., Manila, Philippine Islands, by the J. G. White Management Corp., New York, the operating managers of that company. Mr. Spofford, after graduating from the United States Naval Academy at Annapolis, spent about five years in the Navy. After his retirement in 1911 he was engaged by the J. G. White Management Corp. and was assigned to the staff of the Augusta-Aiken Railway and Electric Corp., Augusta, Ga., and later was made general manager of that company. When the United States entered the war, Mr. Spofford, as a naval reserve-officer, was called to the colors. With the signing of the armistice he was placed on the retired list of the Navy, with the grade of lieutenant commander.

Engineering Affairs

The American Society for Testing Materials will hold its twenty-second annual meeting in Atlantic City, N. J., June 24-27, with headquarters at the Hotel Traymore.

The National Association of Stationary Engineers, New York, State Association, will hold its twenty-fourth annual convention at the Rensselaer Hotel, Troy, N. Y., June 12-14.

Yonkers Association No. 28, N. A. S. E., of New York, held its annual entertainment and ball at the Elks' Club on April 29. The event was largely attended and a general good time was had.

The New England States Association of the National Association of Stationary Engineers will hold its annual convention and mechanical exhibition at Springfield, Mass., July 9-12.

The American Order of Steam Engineers, in conjunction with the American Supply Men's Association, will hold its 33rd annual convention in Atlantic City, June 9-13, with headquarters at Morris Guards Armory, and official headquarters at the Continental Hotel.

Brooklyn Association No. 8, N. A. S. E., held an open meeting on Saturday, May 3, at its rooms, 125 South Elliot Place, Brooklyn, N. Y. Several novelty "stunts" in education were successfully presented and proved highly interesting to the big audience. This introduction of the educational and social features combined is the idea of John H. McGowan, president of the association.

The American Institute of Electrical Engineers will hold its annual business meeting on May 16, in the auditorium of the Engineering Societies Building, New York City, at 8:30 p. m. At this meeting the board of directors will make its annual report, including a complete financial statement for the year ending Apr. 30, 1919. The report of the tellers will also be presented, giving the results of the election of officers for the ensuing administrative year. The Weaver Memorial Tablet, which is to be erected in the headquarters of the Institute "in acknowledgment of the services rendered to the Institute and to the electrical engineering profession by William D. Weaver." will be exhibited at this meeting. Immediately following the business meeting the ceremony of the presentation of the Edison medal will take place. This medal was founded by the Edison Medal Association, composed of associates and friends of Thomas A. Edison, and is awarded annually by the Institute "for meritorious achievement in electrical science, electrical engineering, or the electric arts." The medal has been awarded this year to Benjamin G. Lamme "for invention and development of electrical machinery."

Miscellaneous News

New Power Rates, effective May 18, have been filed at the city clerk's office at Lockport, N. Y., by the International Power and Transmission Co. Increases vary from 10 to 25 per cent. New rates are: First 250 hp., $25 per hp. per year; next 500 hp., $22 per hp. per year; excess of 750 hp., $19 per hp. per year.

A Sawmill Belonging to Tom Crouse, near Victor, Fayette County, W. Va., blew up a few days ago. Mr. Crouse and his son were close to the engine mending a part, when the boiler went up over their heads, demolishing the mill. Beyond a few bruises from falling sticks, Mr. Crouse and his son were unhurt. Debris from the explosion was picked up a quarter of a mile away.

Business Items

Dean Bros., of Indianapolis, Ind., announce the opening of a New York City sales office at 141 Broadway, with H. Meachem as district sales manager.

Edward J. Smith, hydraulic engineers, of New York, announce that they have established an office in El Paso, Texas, in the Mills Building, Rooms 812 and 813.

Briggs & Turivas, of Chicago, Ill., have opened an office in New York City, at 1805 Equitable Trust Building, under the direction of Carl R. Briggs, president of the company.

The Hill Pump Valve Co., of Chicago, Ill., announces that it is maintaining a New York office in conjunction with the Homestead Valve Manufacturing Co., at 1 Franklin St., New York City, with P. L. Rhodes in charge as manager.

The F. W. Freeborn Engineering Co., of Tulsa, Okla., announces that Vincent G. Shinkle has become a partner in the organization. The company is now devoting its activities exclusively to the various phases of the oil industry.

Pioneer Rubber Mills is the name under which the Bowers Rubber Works of San Francisco is now operating. The change in name became effective Apr. 1, but the management and policy of the company continue as under the old name. The Pioneer Rubber Mills will continue to manufacture all the brands that the Bowers Rubber Works established.

The Homestead Valve Manufacturing Co., of Homestead, Penn., has added Charles Nagle to its New York office. Mr. Nagle will call upon the trade within New York City and Brooklyn. It has also placed an additional man, F. H. Thorn, in its Pittsburgh office, who has had several years of experience in the mechanical engineering field. Mr. Thorn will devote his time exclusively to the plants within the Pittsburgh district.

The American Tube and Pipe Bending Co., with offices in the Schofield Building, Cleveland, Ohio, has been formed for the purpose of furnishing bent boiler tubes for any make of vertical water-tube boiler. The active head of the company is A. Wasser, secretary and treasurer. Mr. Wasser was connected with the Erie City Iron Works for thirteen years both in the factory and sales office, and is thoroughly familiar with practical boiler construction.

Meyer, Strong & Jones, Inc., have succeeded to the engineering practice of Henry C. Meyer, Jr., and Bassett Jones, Associated. Mr. Strong was connected for many years with the American Radiator Co., as chief engineer, and is now its consulting engineer. Messrs. Meyer and Jones have been engaged in consulting work in New York City since 1903 and have been responsible for the mechanical, electrical and power equipments of many important buildings and large industrial plants. C. A. King, H. E. Meeker, H. F. Richardson and J. J. Ruckes, who have been associated with Messrs. Meyer and Jones for a number of years, will be in responsible charge of the work in the new organization. The new firm will act as consulting engineers for steam and electrical work, power plants, etc., and will have offices at 101 Park Ave., New York City.

Trade Catalogs

The Vulcan Soot Cleaner Co., Du Bois, Penn., has issued a new bulletin entitled "Vulcan Soot Cleaners for Return Tubular Boilers." This bulletin describes the company's Model "M," front-end type, and Model "R," rear-end type. It also shows how the cleaner is installed in settings of typical construction, and gives results of various tests that have been conducted. A copy may be had free upon request.

The American Steam Conveyor Corp., Chicago, has issued a helpful booklet on the ash-handling question, entitled "Reducing Ash Disposal Costs." The diagram and description of an American steam ash conveyor that saved over $3 a day in ash handling and in the course of eighteen months paid for itself, should be of interest to engineers and power-plant executives. The experience of a number of other users of the steam jet ash conveyor in securing ash-disposal economies are described. Diagrams and photographs of actual installations are also given. A copy of the booklet will be sent free upon request.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.35
Philadelphia, gross tons	4.20@4.90	5.00@5.40
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.65

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7.90	Pea	4.90	6.65
Egg	5.95	7.80	Buckwheat	3.40	5.15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.75 @ 2.95	2.95 @ 3.25
Clearfield County	2.50 @ 2.75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2.75 @ 2.95
Quemahoning	2.65 @ 2.85	2.95 @ 3.10
Somerset County (best grades)	2.65 @ 2.85	2.95 @ 3.10
Somerset County (poorer grades)	2.00 @ 2.35	2.50 @ 2.75
Western Maryland	2.25 @ 2.75	2.50 @ 2.75
Fairmont	2.00 @ 2.25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2.25 @ 2.40
Greensburg	2.25 @ 2.35	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.60 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.95	7.80	Rice	2.75	3.65
Stove	6.20	8.05	Boiler	2.50	3.50
Nut	6.30	8.15	Barley	2.25	3.15
Pea	4.90	6.50	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75		
Williamson County Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2.30	....
2-in. lump	....	....	2.15

Williamson-Franklin rate to St. Louis is $1.07½; other rates 92½c.

New Construction

PROPOSED WORK

Mass., Pittsfield—The Berkshire County Commissioners will install a steam heating plant in the 2 story, 50 x 80 ft. Hall of Records which they plan to build here. Total estimated cost, $100,000. J. M. Vance, Main St., Arch.

R. I., Johnston—The Board of Education will install a steam heating plant in the 5 story, 80 x 150 ft. school which it plans to build in the Thornton Dist. Total estimated cost, $120,000. Hoppin & Field, 32 Westminster St., Providence, Arch.

Conn., Hartford—The city will install a steam heating plant, refrigerating and cold storage machinery in the 1 story, 63 x 122 ft. public market which it plans to build on the corner of Boulevard and Ferry St. Total estimated cost, $100,000. Whiton & McMahon, 36 Pearl St., Arch.

Conn., New London—The S. D. Lawrence Estate, c/o B. A. Copp, 48 Bank St., Trustees, will install a steam heating plant in the 3 story, 56 x 110 ft. business building which it plans to build on Bank St. Total estimated cost, $100,000. Hilderbeck & Langdon, Inc., 253 State St., Arch.

Conn., West Hartford—Sleeper & Parisi, c/o Marchetti & Davino, Arch., 756 Main St., Hartford, will install a vapor heating system in the 4 story, 78 x 136 ft. apartment hotel which they plan to build on Farmington Ave. Total estimated cost, $130,000.

N. Y., Astoria—Glynne & Ward, c/o the Alhambra Theatre, Knickerbocker Ave. and Halsey St., Brooklyn, will install a steam heating system in the 2 story theatre which they plan to build on Grand and Steinway Ave. Total estimated cost, $400,000. T. Lamb, 644 8th Ave., New York City, Engr.

N. Y., Bronx—B. S. Moss, 729 7th Ave., Manhattan, will install a steam heating plant in the 2 story, 125 x 150 ft. theatre which he plans to build on Prospect Ave and 161st St. Total estimated cost, $600,000. De Rosa & Pereira, 110 West 40th St., Manhattan, Engr.

N. Y., Buffalo—The Prudential Life Building is in the market for a generator and machinery for a power plant. J. Lovel, Ch. Engr.

N. Y., New York—The League for Political Education, 15 West 44th St., will install a steam heating plant in the 5 story, 100 x 125 ft. institute which it plans to build on 43rd St., near B'way. Total estimated cost, $150,000. McKimm, Mead & White, 101 Park Ave., Arch.

N. Y., New York—The N. Y. Telephone Co., 15 Dey St., will install a steam heating plant in the 4 story, 103 x 115 ft. exchange which it plans to build on 107th St. and Grand View Place. Total estimated cost, $391,000. McKenzie, Voorhees & Gmelin, 1123 B'way., Engr.

N. Y., New York—The Park Realty Co., 151 West 42nd St., will install a steam heating plant in the 14 story, 25 x 100 ft hotel which it plans to build on 5th Ave and 78th St. Total estimated cost, $250,000. G. E. Blum, 505 5th Ave., Engr.

N. Y., Ossining—The State Hospital Commission, Capitol, Albany, will soon receive bids for the construction of a 1 story, 30 x 30 ft. pump house, in connection with the 4 story, 50 x 200 ft. clinic building which it plans to build at the Sing Sing Prison here.

N. Y., Pelham—The Board of Education will install a steam heating plant in the 2 story, 168 x 171 ft. high school which it plans to build. Total estimated cost, $115,000. Tooker & Marsh, 101 Park Ave., New York City, Engr.

N. Y., Rochester—The city is having plans prepared for the construction of a sewage disposal plant in the 23rd Ward, to include 1 Imhoff tank and pumping system to care for the territory between Lata Rd. and Beach Ave. Address J. F. Skinner, Asst. City Engr.

N. Y., Syracuse—The H. H. Franklin Manufacturing Co., 302 South Geddes St., will install a low pressure vacuum heating system and motors in the 2 story, 70 x 150 ft. addition which it plans to build to its present plant. Total estimated cost, $85,000. R. J. Reidpath & Son, Builders Exchange Bldg., Buffalo, Arch.

N. Y., Syracuse—The New York State Railways plans to expend $200,000 for transmission and trolley line changes, track repairs and street paving here.

Del., Wilmington—The Wilmington Free Institute will install a steam heating plant in the [illegible] story, [illegible] x [illegible] ft. library which it plans to build. Total estimated cost, $100,000. [illegible] & Tilton, 47 Vanderbilt Ave., New York City, Arch.

Md., Baltimore—The Harvey Co., 114 South St., is in the market for two 8-wheel 10 ton locomotive cranes with 40 to 50 ft. booms, 1 clamshell crusher with elevator, a 25 hp. engine on wheels, 11 or 13 in. swing 8 ft. bed second hand engine lathe, back geared and screw cutting, 2 road rollers, 3 wheels, Buffalo-Pittsburg preferred.

D. C., Washington—The Liberty Savings Bank, 1415 New York Ave., N. W., will install a steam heating plant in the 1 story, 25 x 100 ft. bank which it plans to build on [illegible] and Eye St. Total estimated cost, $ 00,000. Holmes & Winslow, 110 West 40th St., New York City, Engr.

Fla., Key West—Norberg Thompson is receiving bids for the construction of a cold storage and distilling plant. Estimated cost, $60,000.

Fla., Mulberry—The International Fertilizer Co., Jacksonville, plans to build a steam plant near here.

La., New Orleans—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install mechanical and electrical equipment at the power house here. Specification No. 3882.

Ohio, Cleveland—The Champion Welding Co., 604 Prospect Ave., is in the market for a 50-60 hp. gasoline motor and a 15-20 k.w.c.d. motor or generator.

Ohio, Cleveland—The Paul Bros. Co., Citizens Bldg., will install a steam heating plant in the 6 story, 99 x 132 ft. factory and garage which they plan to build on East 18th St. and Euclid Ave. Total estimated cost, $175,000. W. S. Ferguson Co., 1900 Euclid Bldg., Engr.

Ohio, Cleveland—The Shaw-Hayden Amusement Co. will install a steam heating plant in the 3 story theatre and commercial building which it plans to build on Shaw and Hayden Ave. Total estimated cost, $100,000. W. Norris, Pres. W. S. Ferguson Co., 1900 Euclid Bldg., Engr.

Ohio, Dover—The Tuscora Rubber Co., c/o the W. C. Owen Engineering Co., Engrs., 1900 Euclid Bldg., Cleveland, will install a steam heating plant in the 3 story rubber factory which it plans to build here.

Ohio, Jewett—The city is having plans prepared by W. J. Sherman, Engr., 613 Nasby Bldg., for the construction of a water supply system, to include the sinking of wells and the construction of a pumping plant.

Ind., Washington—The city plans to remodel and enlarge the electric light and power plant. Widmer Engineering Co., Century Bldg., St. Louis, Mo., Consult. Engr.

Mich., Detroit—The C. B. Bohn Foundry Co., Hart Ave., plans to build a 2 story, 80 x 100 ft. power plant to contain steam plant equipment, consisting of boilers, engine and accessories. Estimated cost, $25,000. C. W. Brandt, Kresge Bldg., Arch.

Ill., Brooklyn—The Terminal R. R. Association, Union Station, St. Louis, Mo., plans to rebuild its 50 x 150 ft. boiler shop, here, recently destroyed by fire, entailing a loss of $75,000. W. Rawden, Room 111, Supt.

Wis., Sheboygan—The Standard Oil Co., 1209 Pennsylvania Ave., is in the market for 4 boilers, to be installed in the 2 story, 40 x 90 ft. filling station which it plans to build on Wisconsin and 4th St. Leiser & Holst, 105 Wells St., Milwaukee, Arch.

Wis., Two Rivers—The Wisconsin Textile Manufacturing Co. will install a 60 hp. steam plant for heating and 20 motors, 2½ to 20 hp. capacity, in the 1 story, 90 x 200 ft. factory which it plans to build on Main St. Total estimated cost, $100,000. Address G. Kirst.

Minn., St. Cloud—The Granite City Investment Co. will install a steam heating and mechanical ventilating system in the 5 story, 120 x 120 ft. commercial hotel which it plans to build on Main St. Total estimated cost, $300,000. Holstead & Sullivan, Palladio Bldg., Duluth, Arch.

Mo., Jefferson City—The State Legislature passed bill authorizing the building of a water trunk line to supply large area in northern Missouri. Work involves pumping equipment, iron pipe, and steel tanks, etc. Address A. L. McCawley, c/o Pub. Serv. Comn.

Mo., St. Louis—The Manufactures Railway, 2925 South B'way., is having plans prepared for changing the switching system from steam to electric. Work involves installing poles, trolleys, transformers and a 24 mi. transmission line. Estimated cost, $200,000.

Mo., St. Louis—The University Investment Co., La Salle Bldg., will install a steam heating plant in the 5 story, 110 x 130 ft. apartment hotel which it plans to build at 4471 Olive St. Total estimated cost, $160,000. Kennerly & Stiegemeyer, Benoist Bldg., Arch.

Ark., Searcy—The Arkansas Hydro-Electric Co., Heber Springs, has had plans prepared by Dickinson & Watkins, Engr., Boyle Bldg., Little Rock, for building a 40 ft. dam and spillway near here. Plans include the construction of a power house and transmission lines. Estimated cost, $262,500.

Okla., Henryetta—The city voted $310,000 bonds for waterworks improvements, to include the installation of additional pumping equipment, filtration plant, settling basins, supply line and distribution system. H. M. La Rue, Supt. of Waterworks. Burns & McDonnell, Interstate Bldg., Kansas City, Mo., Consult. Engr.

Okla., Yale—The city plans election soon to vote on $100,000 bonds for electric light extensions.

Cal., Calexico—The city is having plans prepared by Olmsted & Gillelen, Engrs., 1112 Hollingsworth Bldg., Los Angeles, for the construction of a gas and electric plant here. Estimated cost, $325,000. P. B. Steintorff, City Clk. Noted Jan. 7.

Cal., Fresno—The Fresno City Water Co. plans to drill wells and build 2 pumping stations, 1 near Wilson Ave. and the Atchison, Topeka & Sante Fe Ry., and the other near C and California St.

P. E. I., North Wiltshire—The Department of Public Works, Ottawa, Ont., will receive bids until May 13 for the construction of a 2 story, 47 x 61 ft. power house and laundry at the Dalton Sanitorium here. Plans include the installation of heating apparatus. Estimated cost, $70,000. R. C. Wright, c/o Dept. of Pub. Wks., Arch.

Que., Montreal—The Place Viger Terminal Co. will soon award the contract for the construction of a 10 story, 83 x 150 ft. cold storage plant on Berri St. Complete refrigerating machinery will be installed in same. Total estimated cost, $600,000. A. Chausse, 72 North Dame St., East, Arch.

Que., St. Raphael East—The Montmagny Electric Co., Montmagny, plans 2000 hp. development on the River du Lud here. Estimated cost, $300,000. Gauvin & Co., 147 Mountain Hill, Quebec, Arch.

Ont., Hamilton—The Hamilton Hockey Club plans to build an artificial ice plant in connection with the 1 story, hockey and skating arena which it plans to build. Estimated cost, $200,000.

CONTRACTS AWARDED

Conn., Waterbury—The International Silver Co., 93 Silver St., has awarded the contract for the construction of a 1 story, 45 x 80 ft. addition to its power house, to L. A. Miller, 22 Church St., Meriden. Estimated cost, $25,000.

N. Y., New York—The Commonwealth Ice Co., 7 East 42nd St., has awarded the contract for the construction of a 2 and 3 story, 101 x 169 ft. ice plant, on 67th St. and West End Ave., to the J. H. Taylor Construction Co., 110 West 40th St. Estimated cost, $70,000.

N. Y., Niagara Falls—The U. S. Light & Heat Corp., 3215 Highland Ave., has awarded the contract for the construction of an industrial plant on Highland Ave., to the J. W. Cowper Co., Fidelity Bldg., Buffalo.

N. C., High Point—The city has awarded the contract for installing pumps and motors at the proposed water plant, to the Morris Machine Works, East Genesee St., Baldwinsville, N. Y., for $4,320.

Ill., Chicago—The Hydrox Co., 3542 Normal Ave., has awarded the contract for the construction of a 3 story ice and ice cream factory on Lake Park Ave. and 24th St., to the Midland Engineering & Construction Co., 332 South Michigan Ave. Estimated cost, $225,000.

Ore., Salem—The Valley Packing Co. has awarded the contract for the construction of a 3 story, 82 x 82 ft. meat packing plant at North Salem, to F. J. Leonard, Lewis Bldg., Portland. Plans include the construction of 24 x 36 ft. building for boiler room, rendering tanks and fertilizer department. Total estimated cost, $130,000.

Ont., Sydenham—The Department of Public Works, Ottawa, has awarded the contract for the construction of a power house, heating system, etc., at the Sydenham Military Hospital here, to W. H. Harvey, Kingston. Estimated cost, $65,000. Noted March 18.

Opportunities!

Employment! Equipment! Business!

See pages 91 to 98

—the "Opportunity" Center of the Power Plant Field.

POWER

Volume 49 New York, May 20, 1919 *Number* 20

Ditto Marks and Distinction

By Rufus T. Strohm

There is nothing striking about a ditto mark except its frequent occurrence. It excites no curiosity and makes no strong impressions. It has no more character or individuality than twin tadpoles heading north.

Long ago some enterprising pusher of a quill invented it to save wearisome repetition and shorten his labor. When he got tired of writing "2 lb. of tea at so much" and "6 lb. of sugar at so much," it occurred to him to omit the units of measurement and to indicate them by a couple of commas.

He used the ditto to denote uniformity, and the badge of sameness still clings to it. It symbolizes commonplaceness. It is a confession of being on the same dead level with legions of others. It designates one of a multitude whose units are as much alike as the blades in a steam turbine.

There are numberless human ditto marks—men who have no points of difference from millions of their fellows. They are the chaps who do today the very things they did yesterday, in exactly the same way, and who expect to continue to the end of their existence in the selfsame rut. Their footprints merely parallel those of the day before.

As soon as a man shows the ability to do something that no one else can do quite so well, he loses the mark of the ditto and acquires the insignia of distinction. He is no longer an indistinguishable atom in a mass. He is an individual.

No one ever wrote a ditto mark after the name of Watt, Stephenson, Fulton or Corliss. There was only one of each of them.

These men, together with thousands of others, escaped the stigma of being dittos because they made effective use of their brains. Instead of stagnating, they chose to progress.

The world is on the lookout for men who differ from the ordinary run because of special attainments, and its rewards are worth while. It offers a free field and plays no favorites.

Just how much longer are you going to be satisfied with being a ditto mark?

Power Installation at the Old Hicko

Mechanical equipment of the power station at the largest smokeless-powder plant in the world, erected in record-breaking time. The factors governing the design were speed of construction, low first cost, simplicity of operation and conservation of steel. The equipment includes sixty-eight 823-hp. boilers, fifty-two 350-hp. engines, 17,500 kw. in turbo-generators and thirteen ammonia compressors driven by uniflow engines.

JANUARY 29, 1918, the United States Government awarded to the du Pont Engineering Co. a subsidiary of E. I. du Pont de Nemours & Co., a contract for the Old Hickory Plant, which, as increased by a second contract, was to be the largest smokeless-powder plant in the world, with a rated average daily capacity of 900,000 lb., or 75 times as large as the largest smokeless-powder plant in the United States prior to the European war. Forty-one days later, and 29 days after ground was broken for it, the broad-gage track connection seven miles long had been completed to the site, and on Mar. 8 ground was broken for the plant. The site, sixteen miles from Nashville, Tenn., was at that time a level piece of farming land.

On June first, 84 days after breaking ground for the plant, the first operation—the manufacture of sulphuric acid—commenced, followed on June 23 by the purification of raw cotton; and on the same day, or 107 days after breaking ground, the first guncotton was nitrated. The first powder was granulated on July 2, or 116 days after breaking ground.

When the armistice was signed the entire plant was 93 per cent. completed, approximately $80,000,000 having been expended on construction. The speed with which the construction work proceeded may be judged from the fact that the rate of expenditure was 2½ times the rate of expenditure on the Panama Canal at its peak.

The built-up area of the manufacturing plant is 1800 acres.

The plant and village connected therewith cover an area approximately four miles by one mile, or an actual built-up area of 2360 acres.

Number of manufacturing buildings, 1112.

Number of buildings in village, 3667.

Population for which the village was designed, complete with water supply, sewage disposal, lighting, streets, sidewalks, stores, amusement facilities, etc., 30,000.

Miles of broad-gage track, 54.

Miles of plant industrial track, 32.

Maximum number of men engaged on construction, 33,170.

The conditions to be met in designing this plant were.

1. *Speed of Construction*—The serious shortage of smokeless powder made it necessary that every feature of the design be studied so that the maximum speed in securing materials and completing the construction work could be obtained. Everything else was subordinated to this feature.

2. *Low First Cost*—Because of the probable short time of operation, happily realized, the cost was to be kept at the lowest possible point consistent with satisfactory operation under the strained labor conditions existing. Permanency of structures was to be sacrificed, and operating savings were not considered unless the additional installation cost would be returned in one year's operation.

3. *Operating Simplicity*—To get the plant operating quickly, everything must be as simple as possible, thereby facilitating training of supervisors and labor.

4. *Conservation of Steel*—The minimum of steel was to be used because of the existing shortage.

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*By E. A. Wardenburg, assistant chief engineer, Engineering Dept., E. I. du Pont de Nemours Co.

Powder Plant Near Nashville, Tennessee*

The estimated daily coal consumption was 5000 tons, including 420 tons per day used in the manufacturing processes direct. This coal was to be obtained from the western Kentucky field with a haul of 130 miles. The comparatively short haul combined with the precedence which this plant could secure on delivery and transportation made it possible to figure on a storage capacity of only 20 days' supply, or 100,000 tons. This, however, is a fair-sized coal pile, as it covers 6¾ acres piled 16 ft. deep, with allowance for the necessary tracks for handling.

Western Kentucky coal is likely to develop spontaneous combustion and should not be stored over 8 ft. deep. But this would have required such a large area for coal storage and such a large cost for handling equipment that it was decided to make the pile 16 ft. deep and submit to the cost of digging out fires as they occurred. It was also decided to store crushed coal, although provision was made in the design to store screened coal only if the firing was later found to be too serious. Before operations ceased, a pile of 90,000 tons had been accumulated and was on fire in several places, so that trouble was in sight, although the extra yearly cost of digging out fires was not determined.

The coal-handling plant decided on was worked out with the assistance of the Link-Belt Co., and is shown in plan in Fig. 1 and in elevation in Fig. 2. The headpiece shows a general view of the coal-handling equipment and the bunker. Coal is delivered on three tracks laid on a 1 per cent. grade with a sufficient length above and also below the dumping hoppers to hold 35 cars. It had originally been promised that hopper-bottomed dump cars only would be furnished for this service, and hoppers Nos. 1 and 2 covering tracks Nos. 1 and 2 were laid out for such cars spaced 44 ft. between centers. It was later decided by the Fuel Administration that hopper-bottomed cars could not be secured 100 per cent. of the time and a change was made on the second half of the plant, an extra hopper being added so that side-dump cars, dumping throughout their entire length, could be used, two cars on each track. Hoppers Nos. 3, 4 and 5 accordingly cover tracks Nos. 2 and 3 and are located 28 ft. between centers.

Each hopper is 27 x 27 ft. and delivers to a 42-in. apron feeder with a capacity of 150 tons per hour, which feeds the coal to a 36 x 36-in. two-roll crusher operating at 110 r.p.m. These crushers deliver to 24-in. belts operating at 300 ft. per min., each of which has a capacity of 150 tons per hour.

These belts convey the coal to the first set of inclined belts, which lift the coal to the top of No. 1 silo, a reinforced concrete tower 20 ft. in diameter and 43 ft. high. If the coal is to be delivered direct to the bunker—that is, without storing—it drops through the silo to the second set of inclined belts, to the top and down through silo No. 2 to the third set of inclined belts, which lift it to the top of the bunker, where, by means of the horizontal belts, each provided with a hand-movable tripper, it is delivered to any part of the bunker. Each of the inclined belts is 24 in. wide and at a speed of 600 ft. per minute has a capacity of 300 tons per hour.

If coal is to be stocked, it is diverted through a hole in the upper part of either silo, forming a pile from which it is dug by one of two cranes operating on a four-rail track having a figure-8 shape. Each crane is of 110 ft. radius and is provided with a 3½-ton bucket and has a designed capacity of 200 tons per hour. Coal being reclaimed is dug from any part of the pile desired and thrown against the silo, into which it passes through a hole in the lower part to a feeder that delivers it on one of the inclined belts for delivery to the bunker. The silos are of sufficient size so that in case it is later found necessary to store only screened coal, the crushers and screens can be installed in them.

The principal difficulty experienced with the coal-handling system was with dust. The silos, conveyor runways and top of the bunker were very dusty, and it was necessary to shut down every day long enough to remove the fine dust that had settled, to prevent the machinery from being clogged. It is uncertain whether fully inclosed motors might not have been required.

The coal-handling equipment did not operate for a sufficient length of time to obtain maximum efficiency, but a record was kept for one month, during which time approximately 56,000 tons of coal were unloaded, 85 per cent. of which went direct to the bunkers and 15 per cent. to the stockpile. Considering the total number of men employed for the entire coal-handling equipment, including mechanics for minor repairs and adjustments, 385 man-hours were required per 1000 tons unloaded; however, this crew could have unloaded a considerably larger amount if there had been no delays in waiting for cars. During this time the following record was kept of the time required to unload various types of cars: Hopper-bottomed dump cars, approximately 50 tons, four men for 20 minutes; bottom-dump cars, approximately 40 tons, 8 men for 40 minutes; side-dump cars, approximately 50 tons, 8 men for 30 minutes.

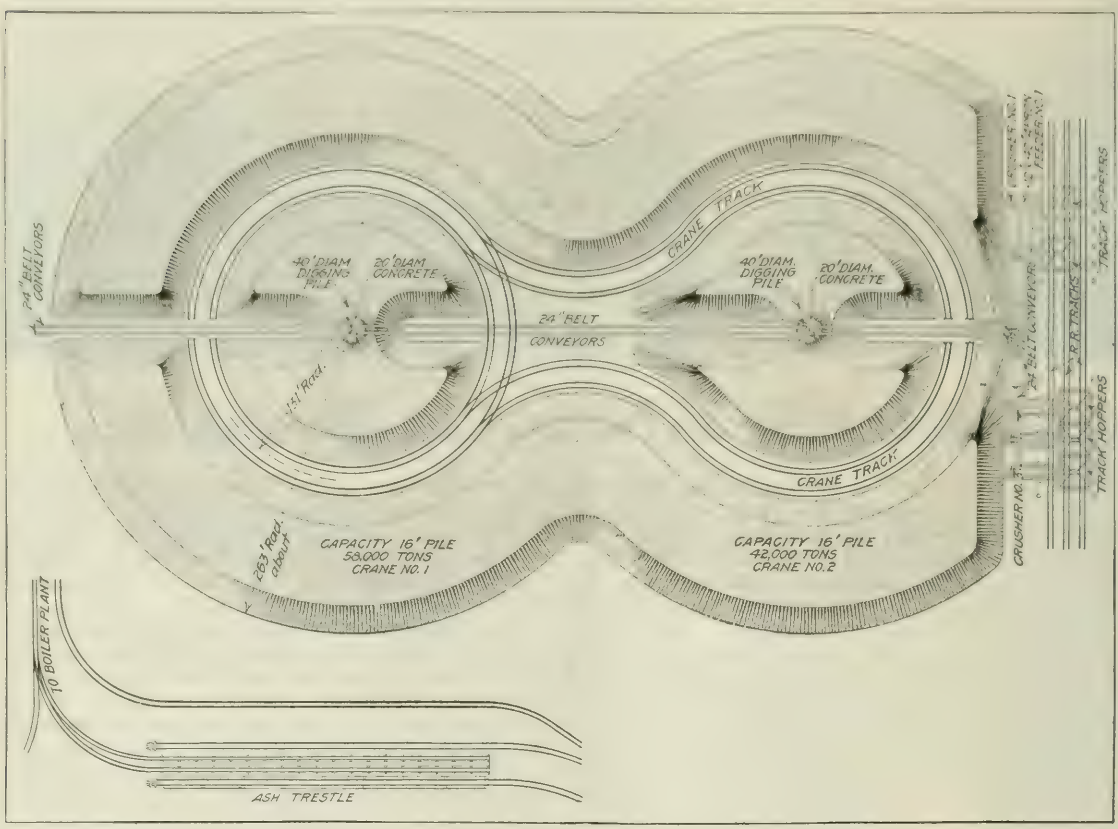


FIG. 1. PLAN OF COAL-STORAGE ARRANGEMENTS

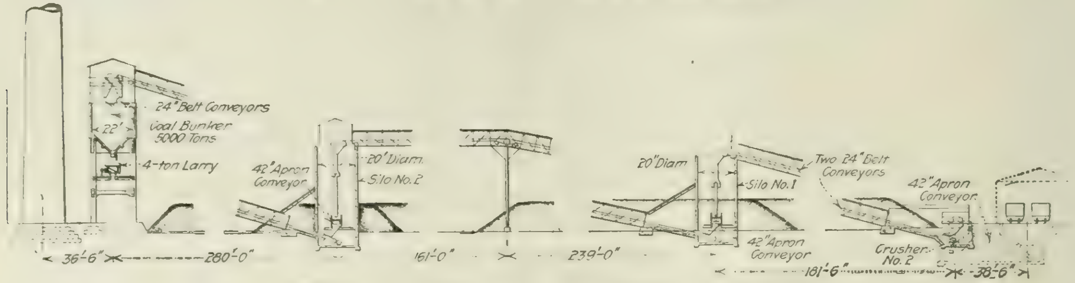


FIG. 2. ELEVATION OF COAL-HANDLING EQUIPMENT

The desire to keep down first cost led to the adoption of a bunker with a storage capacity of only about 24 hours, or 5000 tons. This was made of reinforced concrete to conserve steel and, as a matter of fact, at approximately the same first cost as steel. The bunker was located outside of the boiler plant so that its construction did not interfere with the erection of the boilers. Coal is delivered from the bunker to the boilers by electrically driven weighing larries with a capacity of 4 tons each. The height to the top of the concrete bunker is 63 ft. and to the top of the corrugated-iron building over the belt conveyors is 86 ft. The length is 414 ft., giving a capacity of 12 tons per foot.

It was anticipated that the boiler plant would present difficulties, with an estimated average load 24 hours per day of 86,000 boiler-horsepower at very close to 100 per cent. load factor and with the burning of Western Kentucky coal having a proximate analysis about as follows: Moisture, 6.5 per cent. (separately determined); fixed carbon, 55 per cent.; volatile matter, 31 per cent.; ash, 14 per cent.; sulphur (separately determined) 1.8 per cent.; B.t.u. per lb. of dry coal, 12,600; ash with a low fusing temperature.

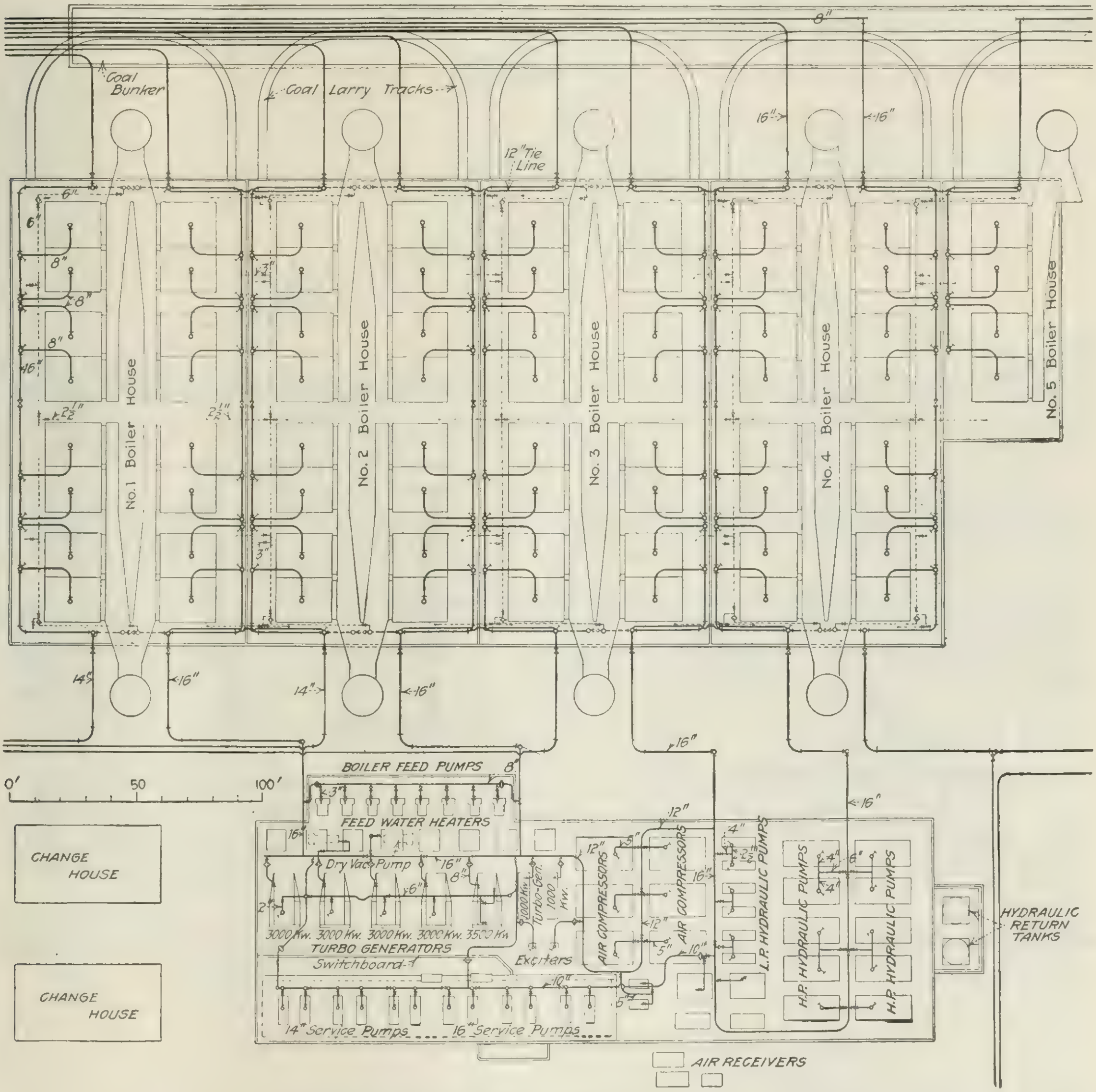


FIG. 3. PLAN OF STEAM PIPING IN POWER PLANT

It was decided to install boilers on the basis of operation at 175 per cent. continuous rating 24 hours per day and with 12½ per cent spares. As far as is known this is a higher 24-hour rating than has been used heretofore with a coal of such poor quality. It might be noted in passing that after the operating force was properly broken in, a full month's operation demonstrated that the designed rating could be secured without great difficulty. Fig. 3 shows a plan of the boiler plant giving also the steam-piping diagram, and Fig. 4 shows a cross-section through one of the boiler houses. There are five of these units side by side in the plant

There are sixty-eight 823-hp. class M-30 Stirling boilers set two in a battery with 8-ft. alleys. Eight boilers are connected by a steel breeching to a radial brick stack 15 ft. in diameter and 200 ft. high above ground level. The stokers are Westinghouse eight-retort. Three stoker engines are provided for each line of eight boilers, the two end engines for regular operation and the center engine for a spare for either set of four boilers. For a double line of 16 boilers there are 4 fans, each with a capacity of 110,000 cu.ft. per min. against 6 in. static pressure, delivering into a plenum chamber directly above. Each fan is geared to a 225-hp. Moore turbine. The fans are proportioned so that at full speed of 970 r.p.m. three fans will carry 14 boilers at 200 per cent. rating and two will carry 14 boilers at 140 per cent. rating. The boiler setting is shown in Fig. 4. Access to the furnace is through three doors in the bridge-wall to facilitate removal of clinkers. It was not determined whether this was actually justified or not, but probably it was not. The ash gate at first installed proved too light for the heavy clinkers obtained and had to be discarded. Fig. 6 shows the gate finally adopted, which proved satisfactory.

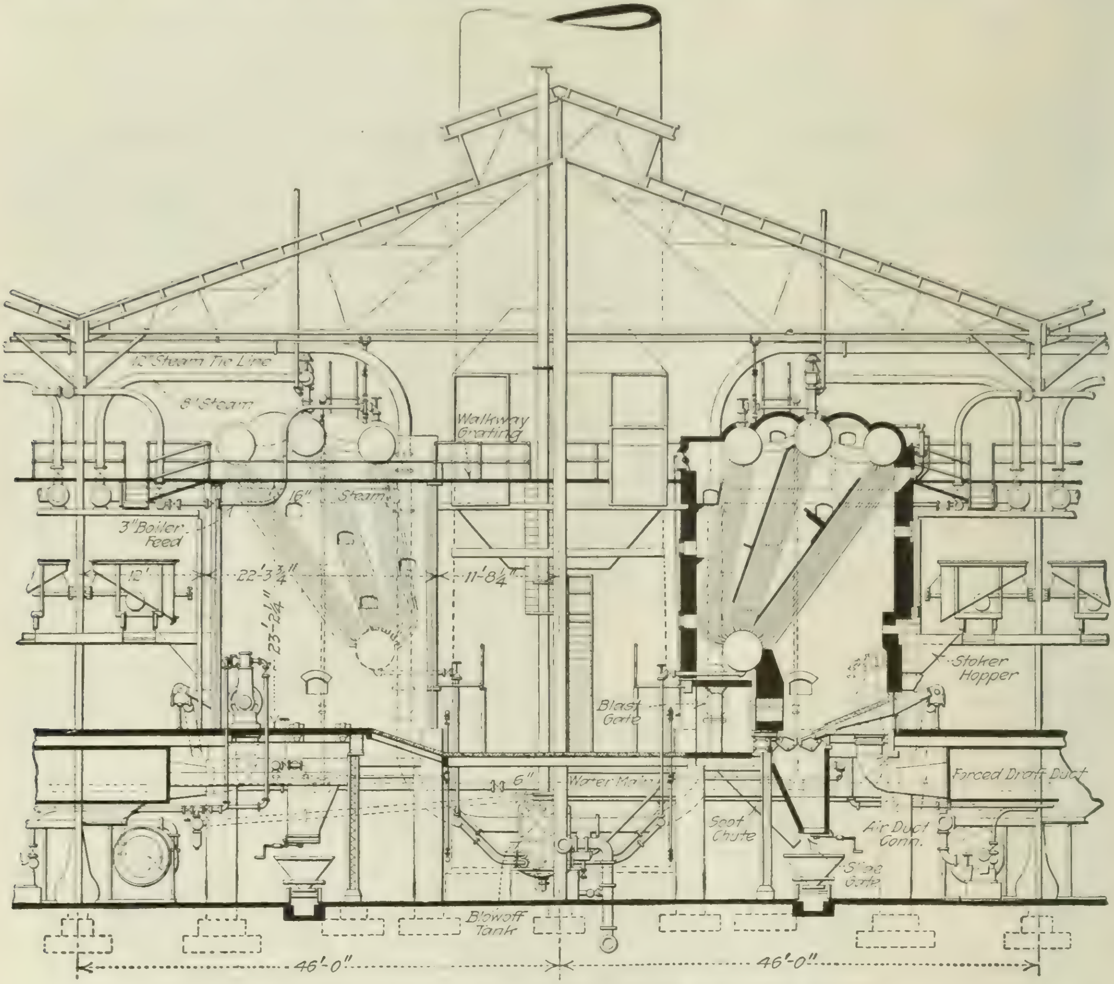


FIG. 4. CROSS-SECTION THROUGH ONE UNIT OF BOILER PLANT

Coal is supplied to the boilers by 5-ton electrically driven weighing larries operating at a speed of 500 ft. per min. and supplied with current at 110 volts to minimize the danger if a man should touch the contact rails. One larry could supply 16 boilers delivering 48 tons of coal per hour. Extension hoppers were provided for the stokers, each boiler having a capacity of 5 tons, or 1¾ hours, at 175 per cent. rating.

The plant was designed to carry an average steam pressure of 160 lb. per sq.in., this being a compromise between the higher steam pressure desired for economical operation of prime movers and the lower steam pressure desired for minimum radiation losses on long transmission lines. The cost of pipe lines also had a bearing on this decision—on the one hand the greater difficulty in securing a tight job with the higher pressure, and on the other the smaller sizes of pipe which could be used to deliver the required pressure at the operating buildings.

Feed water is hand-regulated, although if the plant had continued operation, automatic regulators would have been provided, the labor saving and additional security against high or low water justifying the installation.

Ground was broken for the boiler plant on Apr. 1, and 50 days later the first boilers went into regular operation. When the armistice was signed, seven months after breaking ground, 56 of the boilers with all equipment were entirely completed and the remaining 12 would have been entirely completed in two weeks more.

The building up from nothing of a highly efficient operating organization for such a large boiler plant is the work of years, and not of a few months. It is not surprising, therefore, that difficulty was experienced at first in maintaining the high rating desired, 175 per cent., with coal far from good. During the last month of operation, however, this rating was secured without difficulty and with a fair over-all efficiency—approximately 68 per cent. Difficulty was also experienced with brickwork repairs, but with better operation of furnaces as the operators became more skilled, it was anticipated that these difficulties would have been much lessened.

Operation of a boiler plant at such a high rating and with such a small percentage for spares requires water of good quality. The Cumberland River water has an average mineral analysis about as follows:

	Grains per Gal.		Grains per Gal.
Calcium carbonate	3.26	Sodium carbonate	0.06
Calcium sulphate	0.13	Sodium sulphate	0.78
Magnesium carbonate	0.64	Sodium chloride	0.71
Silica	0.66	Volatile and organic	1.26
Iron oxide and alumina	0.52		
		Total solids	8.02

This water can be classed as reasonably good and it was not anticipated that difficulty would be experienced with it. The best criterion of a boiler water, however, is its action in the boiler. It was found that the one large boiler plant using this water, and with a returned condensate from surface condensers of 85 per cent., had so much trouble with boiler scale that a water-softening plant had to be provided for the 15 per cent. makeup water.

Because of the enormous size of the softening plant (7,000,000 gal. per day) it was decided not to provide this plant at first, but to watch the boilers very carefully. This decision was amply justified, the boilers being almost entirely free of scale. As a matter of fact, as far as the water surfaces were concerned, the boilers could have been operated for three-month periods.

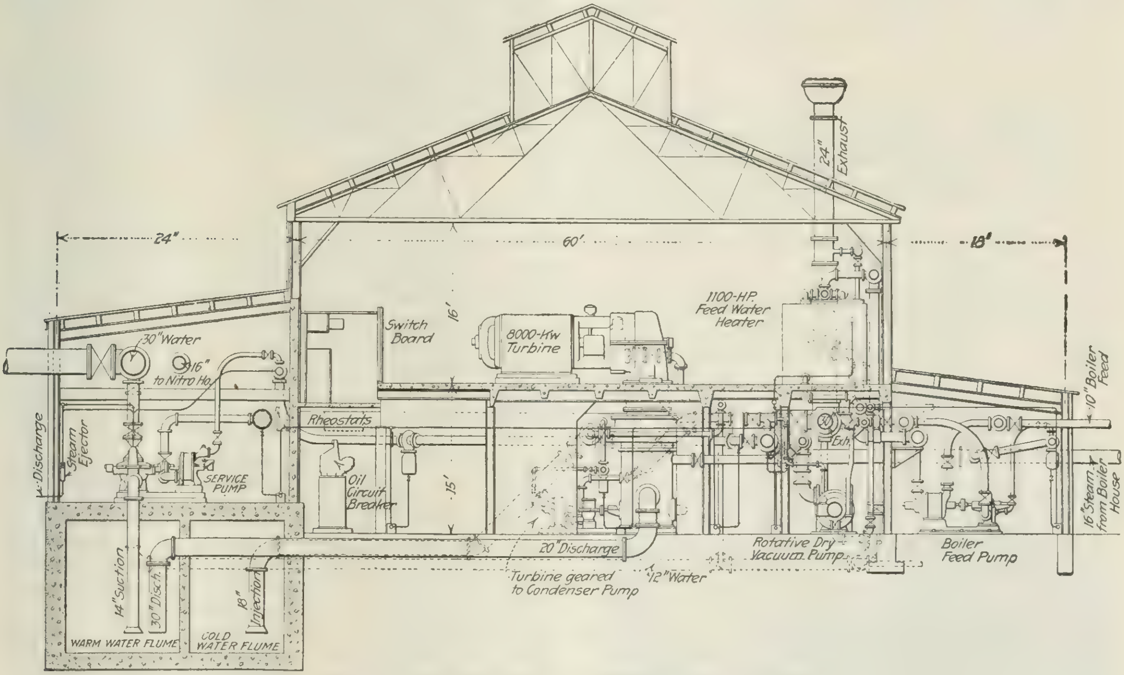


FIG. 5. CROSS-SECTION THROUGH POWER HOUSE

The handling of ash is always a problem and at Old Hickory it was of unusual difficulty because of the amount of ash, which was estimated for full operation at 900 tons per day. A better idea of this amount may be secured by considering that this ash, dumped in a waste bank 10 ft. high, would have necessitated moving 650 lin.ft. of dump track 8 ft. sideways every 24 hours.

The ash hoppers under the boilers have a capacity for 7 hours' operation at 175 per cent. rating. From these the ash is dumped into side-dump cars of 40 cu.ft. capacity. Storage-battery locomotives haul trains of these over a level track onto a trestle, where the ash is dumped into broad-gage cars. Trains of these were to be hauled to the ash dump by a saddle-tank locomotive, although during the actual operation of the plant all the ash produced was used for roads and ballasting of tracks.

In the power house adjacent to the boiler plant are located the electric units, air compressors, hydraulic pumps, water-service pumps and boiler-feed equipment. Fig. 5 is a transverse section through the two-story part containing the electric units. The difference from the usual central station is indicated by the fact that whereas the boiler capacity installed would carry a continuous load of 175,000 kw., just 10 per cent. of this, or 17,500 kw., was the installed capacity at Old Hickory. This capacity is made up of two 1000-kw. Allis-Chalmers noncondensing, one 3500-kw. General Electric condensing, one 3000-kw. General Electric mixed-pressure and three 3000-kw. General Electric condensing turbines, all 60-cycle 2300-volt machines. Each of the condensing turbines is connected directly to a jet condenser in the basement beneath. These condensers draw injection water from one side of the service-water flume and discharge into the other side. This provides a continuous supply of condensing water and delivers warmer water to those portions of the plant which can use warm water satisfactorily. Each turbine pump is driven by a geared turbine, and two rotative dry vacuum pumps serve the four condensers on the 3000 kw. turbines. With the two noncondensing machines and the mixed-pressure machine it was expected that almost an exact heat balance would be obtained the year round.

Three exciters are provided, two of 100-kw. capacity each, direct-driven by General Electric turbines, and the third a 75-kw. motor-generator set. With the simultaneous failure of two of the exciters, the remaining one can carry 70 per cent. of the total alternating-current load.

The switchboard, shown in Fig. 7, was designed for simplicity of construction. It is of slate and comprises 7 generator panels, 3 exciter panels, 1 regulator panel and 21 single circuit feeder panels. The oil switches are mounted on the wall back of the switchboard and are hand-operated through bell cranks. The outgoing circuits pass through an overhead concrete duct to a steel distributing tower outside the power house. General plant distribution is at 2300 volts with 440-volt motors and 110- to 220-volt lighting. For the river pumphouses, however, transmission is at 6600 volts from 2300- to 6600-volt transformers at the base of the distributing tower.

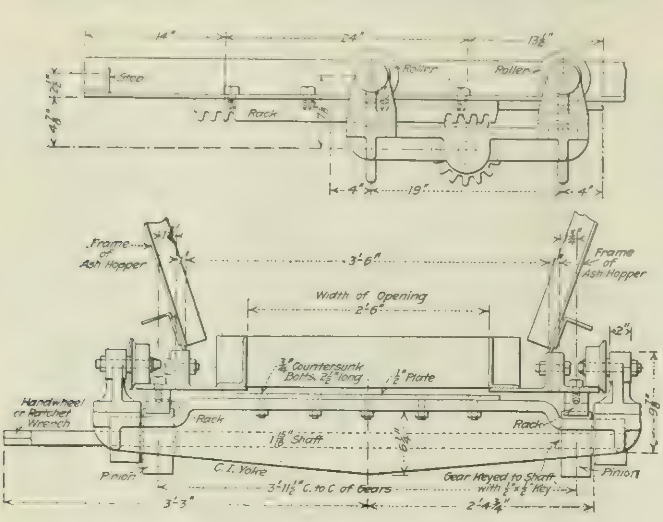


FIG. 6. DETAILS OF ASH GATE

Compressed air for general plant use, such as blowing acid, operation of acid pulsometers, etc., is supplied at 60 lb. pressure from six 15 and 26 x 20 x 24-in. compound steam, duplex air Laidlaw-Dunn-Gordon compressors with a displacement of 2570 cu.ft. each at 150 r.p.m. Compressed air for operation of shop tools is supplied at 110 lb. pressure by two 9 and 17 x 15 and 9 x 12-in. compound steam, compound air Laidlaw-Dunn-Gordon compressors having a displacement of 630 cu.ft. per min. each at 250 r.p.m. All these compressors exhaust to the feed-water heaters.

The fabrication of smokeless powder requires large amounts of water under pressure. The so-called high-pressure water at 3500 lb. pressure is supplied by ten 25 and 38 x 4⅝ x 24-in. Worthington compound duplex pumps with a capacity at 20 r.p.m. of 140 g.p.m. each. A better idea of the size of this pumping installation can be obtained perhaps from the fact that the estimated steam consumption with plant at full operation was 5000 boiler-horsepower. Connected to the high-pressure system are two 42 x 11¼ x 50 in. hydro-pneumatic accumulators with a capacity of 22½ gal. each. These really act as pressure regulators, starting and stopping the pumps by cables attached to balanced steam valves on the pump supply pipes.

Low-pressure water at 300 lb. pressure for the first movements of presses is obtained from six 14 and 20 x 7½ x 18-in. Worthington compound duplex pumps with a rated capacity of 400 g.p.m. each at 29 r.p.m. These pumps are connected to a pressure tank, a float valve in which controls the steam supply to the pumps.

All the hydraulic pumps are piped to exhaust against 15 lb. back pressure for use in some of the plant operations, with sectionalizing valves so that some of the pumps can exhaust to the feed-water heaters in the summer time.

On the turbine floor are placed eight 11,000-hp. Warren-Webster feed-water heaters supplying feed water to eight 8-in. Alberger three-stage pumps having a capacity of 1050 g.p.m., or 15,000 hp. each, and each direct-driven by a 181-hp. Alberger turbine at 1900 r.p.m. The power house also contains 14 water-service pumps and two 1500-g.p.m. duplex Underwriters' pumps for maintaining pressure on the fire mains.

Fig. 3 shows the steam-piping diagram. It will be noticed that each kind of service is connected to at least three sections to avoid interruptions in case of failure of any portion of the steam piping. Every other system of piping was sectionalized in a somewhat similar manner. Ground was broken for the power house on Apr. 2 and one unit of each kind was placed in regular operation on June 17, or 75 days later. When the armistice was signed, seven months after breaking ground, the power house was complete in practically every detail.

The use of refrigeration for condensation of solvent vapors in the operation of recovering solvent from the powder made necessary the construction of a refrigerating plant of 3250 tons refrigerating capacity—larger than any other known refrigerating plant. This plant was built as a separate unit instead of as an adjunct to the power house, to reduce the cost of brine lines and avoid the presence of ammonia in the power house. There are thirteen 18 x 24-in. De La Vergne horizontal double-acting ammonia compressors each rated at 260 tons at 160 r.p.m. at a head pressure of 185 lb. and a suction pressure of 23 lb., corresponding to 20 deg. F. brine. Each compressor is direct-connected to a 370-hp. 23 x 24-in. Ames Uniflow engine.

The engines driving the ammonia compressors operate condensing by means of two Schutte & Koerting jet condensers. Water for these condensers is supplied by means of motor-driven pumps from the discharge from the ammonia condensers, the tail water flowing by gravity back to the plant for further use in the manufacturing operations, thus using this water three times. In connection with the refrigerating plant a 60-ton ice manufacturing plant was provided to take care of company hotels and commissaries and for cooling of drinking water.

The purification of guncotton and raw cotton requires enormous quantities of water—345 lb. water for each pound of guncotton made—which must be practically free from turbidity, alkaline and not too high in mineral impurities. In addition, large quantities of water are required for cooling in acid manufacture, alcohol rectification and ether manufacture. This made the development of the water supply one of the major problems of the plant.

The Cumberland River, as is usual with southern rivers, is subject to heavy rises and records from previous years showed a flood stage of 55 ft. above low water, which was the rise for which the river pumphouses were designed. There are two duplicate pumphouses, like that shown in Fig. 8, each containing five 14-in. Worthington pumps rated at 8500 g.p.m. each, at 112 ft. head and operating at 1170 r.p.m. Each pump is connected to a 300-hp. General Electric 2300-volt induction motor. In each house is provided space and foundation for a sixth pump and space by crowding and rearranging the stairway for a seventh pump. The estimated consumption of the plant for which these pumphouses were designed is 100,000,000 gal. per day, sufficient for a city of 1,000,000 inhabitants.

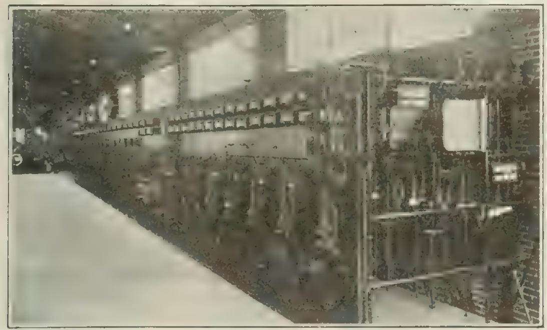


FIG. 7. VIEW OF SWITCHBOARD IN POWER HOUSE

The services of the Foundation Company of America were secured to design the concrete details, and this company furnished a foreman to supervise the construction work. Construction was carried on by building a cofferdam of lock steel piling to bedrock and dewatering the site. The soil and loose rock were removed and keys cut into the solid rock to prevent sliding. The work was flooded out twice, causing a loss of several days until the river receded sufficiently to allow of dewatering and starting work again.

In a sump below the floor line is a vertical pump with a capacity of 400 g.p.m. and driven by a vertical shaft by a motor above the flood stage. This pump is provided so that in case of a leak or break in a pump casing the pumphouse could be drained without too serious a loss of time. It also takes care of any leakage, which is, as a matter of fact, almost completely absent. A fan is provided to blow fresh air to the bottom of the structure to displace the air warmed by the motors. This is a necessity for summer operation.

The pumps discharge into a 36-in. header from which two 42-in. risers are taken. The four 42-in. risers from the two pumphouses combine into three 42-in. woodstave mains which deliver the water to the plant 8000 ft. away.

On top of the concrete structure and housed in a light corrugated-iron structure are three 600-kw. transformers to reduce the voltage from 6600, which is the transmission voltage from the plant, to 2300, the motor voltage. There are two 6600-volt lines following entirely different routes from the plant to minimize possibility of interference by any accident.

Power to drive guncotton pulping and poaching machinery and also for the machinery in cotton purification plants is furnished by 52 Allis-Chalmers Corliss engines, 18 x 36 in., rated at 350 hp. each at 120 r.p.m. Steam from these engines is just sufficient to heat the water required in the process. The use of engines instead of motors for this work resulted in a very large saving in both installation cost and operating cost.

The outside piping systems, to distribute such large amounts of power over such a large area, can best be appreciated perhaps by the following figures, which are for main lines and do not consider branches:

	Total, Feet	Total Miles
Steam mains (of which 24,000 ft. is 16-in.)	176,000	33
Compressed-air mains	58,000	11
Water mains, excluding fire mains	110,000	21
Fire mains	180,000	34
Brine mains	56,000	11
Hydraulic mains (including high-pressure, low-pressure and return)	36,900	7
Total main lines	......	117

In the steam distribution for the cotton purification plants and for the guncotton plants headers are run from which branch lines are taken to each unit and into which steam is fed by lines from the boiler plant. The whole system is sectionalized so that the failure of no section can result in the shutdown of more than two out of the nine units. Expansion is taken care of by changing the elevation with long-radius bends or by inserting an expansion joint made up of long-radius bends and straight pipe sections approximately every 500 ft. It will surprise many, no doubt, to know that the radiation loss from this extensive system with a maximum transmission of 6400 ft. and with pipe covering about an inch thick is well under 5 per cent.

These distributing systems, together with the enormous amount of piping of all kinds in the various manufacturing buildings and power plant, constitute perhaps the largest single piping job ever undertaken. The work was carried on by the organization and manufacturing shop of the B. F. Shaw Co., which were taken over temporarily by the du Pont Engineering Co.

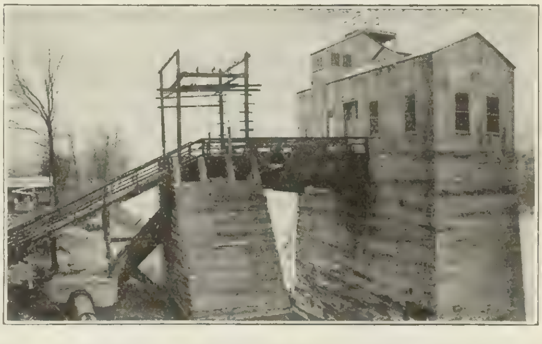
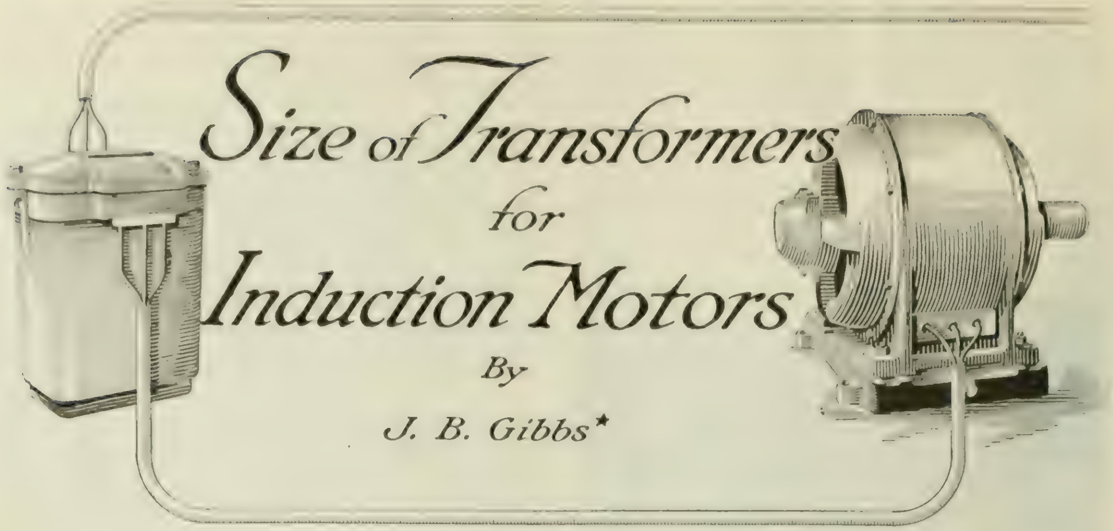


FIG. 8. PUMPHOUSE, SHOWING CONCRETE FOUNDATION

This article would not be complete without a word of appreciation for those manufacturers who, with shops full of other work and confronted with great difficulties in securing labor and materials, nevertheless turned out as fast as required the equipment that made it possible to complete the power installation in record-breaking time.



Size of Transformers for Induction Motors

By

J. B. Gibbs*

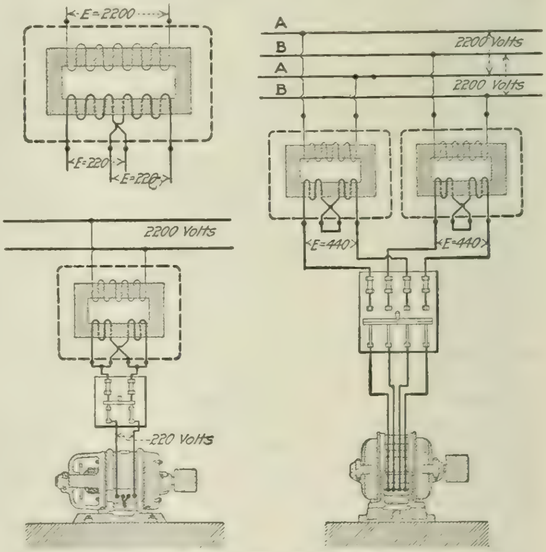
The practical electrician and the operating engineer are frequently confronted with the problem of determining the size of the transformers to specify for a given size motor. This question is discussed and methods are given for solving the problem to meet a variety of conditions that occur in practice

IN SELECTING transformers to be used with induction motors, there is a large field for the use of good judgment. The transformers must not be too small, or they will burn out when the motor is loaded. If they are too large, it means unnecessary energy losses in the system and unnecessary investment in the transformers. So it is important to know what should be expected of motors and transformers and how to group them.

Probably the most common case will be where a motor wound for 220 or 440 volts is to be run from a power line at 2200 volts. Transformers for this kind of service are built in two classes. The first class has its low-voltage winding divided into two parts, which may be connected in series for 220 volts, or in parallel for 110 volts. The second class has the low-voltage winding in two parts, which give 440 volts when connected in series and 220 volts when connected in parallel. Fig. 1 shows the development of the winding of a transformer for 2200 to 440 or 220 volts.

The size of transformers to be used with a given motor depends on several factors. According to the Standardization Rules of the American Institute of Electrical Engineers and of the National Electric Light Association, transformers are designed to have a temperature rise of 55 deg. C, above the surrounding air when carrying continuously the load indicated on the name-plate. The reason for this is that if a transformer is located in a hot place (45 deg. C. or 113 deg. F. is taken as the standard air temperature), and loaded, the coils will reach 45 + 55 = 100 deg. C., which is as high a temperature as the insulation should be called upon to stand continuously.

Now a motor rarely has an absolutely uniform load, and short-time peaks much above the rating of the transformers will be harmless if the load between the peaks is correspondingly low. Usually, unless the installation is important enough to warrant a test of actual load conditions, the best that can be done is to estimate the size of the transformers required from the size of the motor, and then to inspect them at intervals for a few days or a few weeks to find whether they are getting too hot. If any doubt exists as to the transformers to use, it is better, of course, to err on the side of safety.



FIGS. 1 TO 3. DIAGRAMS OF TRANSFORMER AND INDUCTION-MOTOR CONNECTIONS

Fig. 1—Upper left-hand corner: diagram of transformer connections. Fig. 2—Lower left-hand corner: diagram of single-phase motor connected to transformer. Fig. 3—On the right: diagram of a two-phase motor connected to two transformers.

Another thing that sometimes causes uncertainty is the difference in the way of rating motors and transformers. Motors are always rated in horsepower or in kilowatts—usually in horsepower—while transformers are always rated in kilovolt-amperes. With direct-current motors the product of the volts by the amperes gives the power in watts actually put into the motor; but with alternating-current motors this is not true. With alternating-current motors the product of volts by amperes must be multiplied by another factor, called the "power factor," to give the watts. That is, if two motors to which is being supplied the same amount of power at the same voltage, one alternating current and the other direct current, the alternating current will require more current than the direct-current machine. And since it is current and not power that heats the transformers, they must be large enough to take care of this extra current. The transformers must also supply the losses that take place in the motor itself, which makes them still larger.

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*Engineer, Transformer Department, Westinghouse Electric & Manufacturing Co.

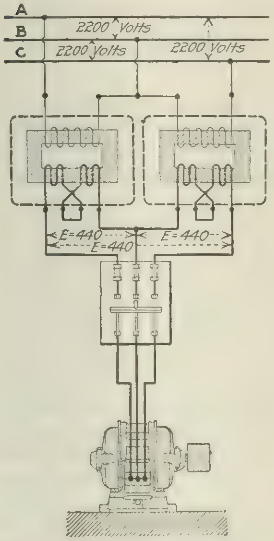


FIG. 4. THREE-PHASE MOTOR CONNECTED TO TWO TRANSFORMERS IN OPEN-DELTA

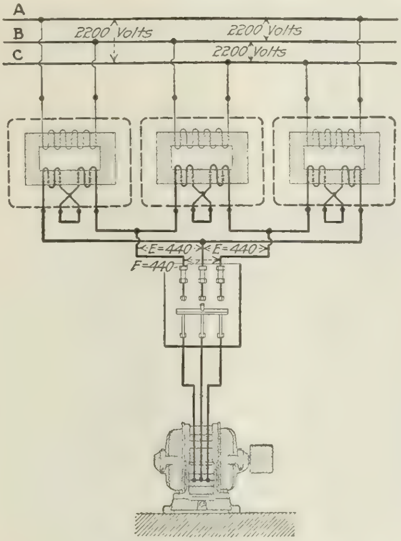


FIG. 5. THREE-PHASE MOTOR CONNECTED TO THREE TRANSFORMERS IN CLOSED-DELTA

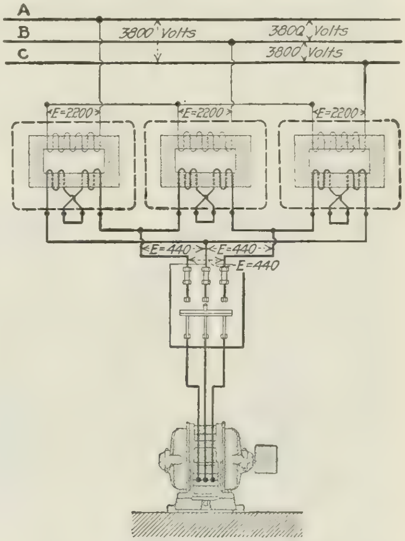


FIG. 6. THREE-PHASE MOTOR CONNECTED TO THREE TRANSFORMERS STAR TO DELTA

Methods for approximating the correct size of transformers for various conditions are given in what follows. They are based on the assumption that the motor will carry about full load and will have an efficiency and power factor as good as a typical modern induction motor. The simplest case of alternating-current motor connection is a single-phase motor, as shown in Fig. 2. Two wires are run from the secondary of the transformer through fuses and a switch to the motor. Small motors are usually connected to the lighting circuits and treated as a part of the lighting load, but the larger sizes are likely to cause flickering of the lights, and are therefore better run from separate transformers. Single-phase motors are built in sizes ranging from a small fraction of a horsepower up to about ten horsepower. The approximate size of transformer for a single-phase motor may be found from the formula,

kv.-a of transformer = hp. of motor × 1.25

In most cases where power is required, it can be better supplied by polyphase motors than by single-phase motors, because the former are cheaper, have better operating characteristics and are more sturdy and reliable. As a rule, the larger the motor the higher will be both its power factor and efficiency. High-speed motors generally have better power factor than slow-speed motors, and 25-cycle motors have better power factor than corresponding 60-cycle motors. As a rough general rule, which is easy to remember, it may be said that each horsepower of the motor rating will need one kv.-a. of transformer rating. The figures given in what follows are somewhat closer than this, but in order to use standard transformers it will often be necessary to select them larger or smaller than indicated by the figures.

Fig. 3 shows a two-phase motor connected to a two-phase line. In this case two transformers are needed, as shown, and the size of each, if the motor is small (say 25 hp. or less) may be taken as

kv.-a of one transformer = hp. of motor × 0.58

For large two-phase motors, say 100 hp. or more, the size of transformers may be found from the expression,

kv.-a of one transformer = hp. of motor × 0.46

In operating three-phase motors from three-phase lines, we have a choice of several connections. Fig. 4 shows the open delta, or "V" connection, which is frequently used, especially for motors of the smaller sizes. In this connection the current in the transformers is out of phase with the voltage, so a larger total kv.-a of transformers is needed than with the delta connection. On the other hand, only two units are needed instead of three, and this is an advantage in installation. For small motors connected as in Fig. 4 the size of each transformer may be found from the formula,

kv.-a. of one transformer = hp. of motor × 0.67

and for large motors,

kv.-a of one transformer = hp. of motor × 0.53

The delta connection, shown in Fig. 5, is also much used for transformers supplying three-phase motors. One advantage of this connection is that in case of trouble with one transformer it can be cut out, and the remaining two transformers will operate in open delta and allow the motor to carry about 58 per cent. of its normal load. The size of the transformers for small motors is,

kv.-a of one transformer = hp. of motor × 0.39

and for large motors is,

kv.-a of one transformer = hp. of motor × 0.31

Another connection frequently used is the star, or

"Y," connection, shown in Fig. 6. It is especially convenient where it is desired to run three-phase motors from a three-phase 3800-volt line, using standard 2200-volt transformers. One high-voltage terminal of each transformer is connected to a common junction, and the remaining three terminals are connected to the three line wires, as shown. The size of transformers needed is the same as for the delta connection given in the foregoing.

Sometimes it is desired to operate two-phase motors from a three-phase power line, or vice versa. The usual connection for this case is shown in Figs. 7 and 8. Two transformers are needed, and the three-phase side is provided with special taps. Fig. 7 shows a two-phase motor connected to a three-phase line. The "main" transformer, shown at the left in the sketch, has a lead brought out from the middle point of its high-voltage winding, and this lead is connected to an 86.6 per cent. tap on the "teazer" transformer. The other end of the teazer winding is connected to the three-phase line. This causes the voltages in the secondary windings of the two transformers to be 90 deg. apart and equal in magnitude; that is, to be two-phase voltages. The connection of a three-phase motor to a two-phase line is shown in Fig. 8. In this case the special taps are in the low-voltage windings, in the same relative positions as above. For small motors connected according to either Fig. 7 or Fig. 8 the size of transformers is

kv.-a of one transformer = *hp. of motor* × 0.67

and for large motors,

kv.-a of one transformer = *hp. of motor* × 0.53

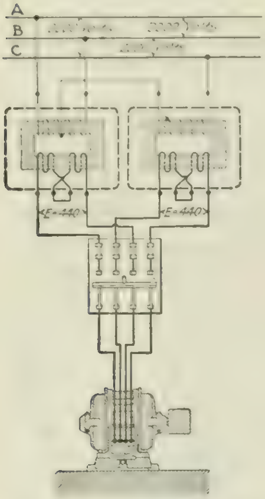


FIG. 7. CONNECTIONS FOR OPERATING A TWO-PHASE MOTOR FROM A THREE-PHASE LINE

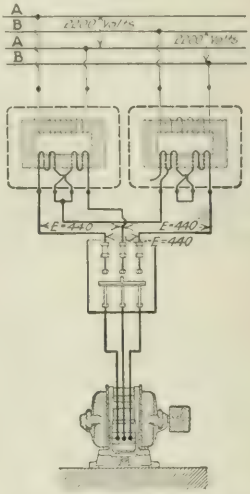


FIG. 8. CONNECTIONS FOR OPERATING A TWO-PHASE MOTOR FROM A TWO-PHASE LINE

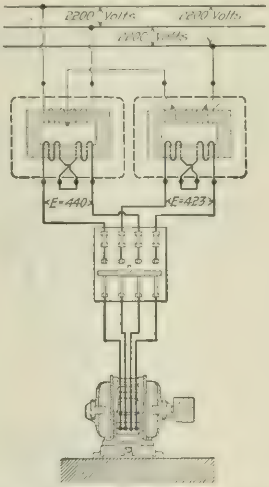


FIG. 9. CONNECTIONS FOR OPERATING A TWO-PHASE MOTOR FROM A THREE-PHASE LINE

Small motors are started by closing the main switch and connecting the motor directly to the line, as shown in all the figures, but for large motors this would cause too large a rush of current, so some kind of starting device, or "compensator," is used. This is connected between the motor and the main switch and usually consists of auto-transformers, or choke coils. There are several kinds of compensator on the market, and as a diagram of connections always accompanies the compensator, they are not included in the figures given here.

The direction of rotation of a single-phase motor can be reversed by interchanging the leads of the starting winding or running winding on motors of the split-phase type or by shifting the brushes on motors of the repulsion type. The details of this operation depend on the arrangement of leads, and instructions are always sent with the motor. Two-phase motors may be reversed by interchanging the two leads of either phase, and three-phase motors may be reversed by interchanging any two leads.

A volume might be written on the subject of emergency connections, because there are so many possible emergencies, but the operator must always depend finally on his own judgment and knowledge. It may be of assistance in forming a judgment in any particular case to point out certain facts and relations.

Two transformers can usually be connected in parallel to give an output equal to the sum of their ratings. This is true especially if the two transformers were built by the same manufacturer and are not too far different in size. For instance, a 10-kv.-a. transformer would probably operate satisfactorily in parallel with a 5-kv.-a. or a 25-kv.-a. or any size between the limits, but it might be doubtful wisdom to connect a 5-kv.-a. in parallel with a 100-kv.-a. unit. In some cases the characteristics of large transformers are such that they will not divide the load in proportion to their ratings when connected in parallel. This merely means that the output of the bank is limited by the transformer which takes more than its share. In case of doubt it is well to ask the manufacturer whether the two transformers in mind are suitable for operation in parallel, although this is seldom necessary for transformers smaller than 100 kv.-a.

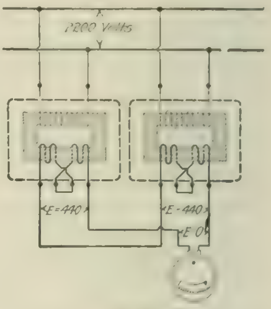


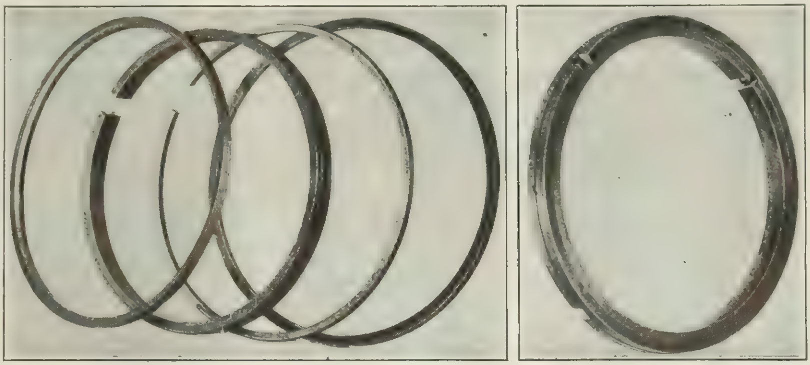
FIG. 10. METHOD OF CHECKING PARALLEL-CONNECTED TRANSFORMERS

In making a parallel connection between transformers it is always well to check their polarity, especially if they were made by different manufacturers. This may conveniently be done as shown in Fig. 10. Connect one transformer to the primary and secondary lines, as shown at the left of the sketch, and connect the other transformer to the primary line and to one side only of the secondary line. Now take a voltmeter, or incandescent lamps, and test between the open side of the transformer and the other secondary line wire as shown. If no voltage is indicated, the connection is correct and may be completed. If the voltmeter shows a reading or the lamps light, the leads of the second transformer must be reversed. If lamps are used for this test, enough should be connected in series to take up double the voltage for which the transformers are connected.

Two-phase motors may sometimes be run from three-phase lines using standard transformers. For the "main" transformer select one which has its primary wound for 2200 or 1100 volts, series-parallel, and for the "teazer" transformer one which has two 5 per cent. taps in the primary. These are both standard arrangements, and the ordinary central station usually has both kinds. The two transformers are connected as shown in Fig. 9. This gives a two-phase voltage which is unbalanced and which consequently puts the motor at a disadvantage; but it will enable the motor to run and may sometimes save a long delay in getting the proper special transformers.

Du Bois Piston Ring for Internal Combustion Engine

A piston ring designed for internal-combustion engine pistons is shown in the accompanying illustrations. It is of the composite type and is formed by a plurality of rings, coacting to produce a tight packing ring. The carrier, or bull ring, has an outer annular groove in the central plane of the ring, which forms the seat for an inner expansion ring. Both rings have gaps adapted to form a straight joint. The carrier also forms an expansion ring the action of which is more limited than that of the inner expansion ring, owing to the difference in construction.


ASSEMBLED RING AND RING PARTS

Packing rings are mounted to encompass the carrier ring and the expansion ring. Each of the packing rings has on its inner face a bevel against which the expansion ring bears, and acting on the bevels tends to move the two packing rings apart on the carrier ring. As the separation of the packing rings is limited by the width of the piston-ring groove, the expansion ring will also control the lateral expansion of the packing rings if the carrier fails to sufficiently expand the packing rings laterally. The result is a longitudinal and lateral motion.

The bevels of the rings are at angles of 45 deg. to the bearing faces of the packing rings, which are made either corrugated or smooth. The gaps in the packing rings may form a straight joint, or a lap joint may be used if so desired. The packing rings are provided with elongated notches in the proximate faces, into which enters a pin which is anchored in the carrier ring; the pin also passes through the gap of the expansion ring. The pin is set at an angle of 135 deg. to the gap of the carrier ring, and the notches in the packing rings are formed at oppositely directed angles of 45 deg. from their notches. Therefore the joints of the packing rings are 90 deg. apart, and one of them is 180 deg. and the other 90 deg. from the joint of the carrier, giving the best lateral expansion.

In cases where it is desirable to dispense with the carrier ring, a seat for the expansion ring is provided directly in the piston groove, for which purpose a groove is depressed from the bottom of the groove. The packing rings are also, if desired, reduced at their upper outer faces to provide space for secondary packing rings, the gaps of which rings have straight joints. The secondary packing rings present as much working surface as the primary rings which carry the secondary rings.

In this construction of composite rings, the elongated notches in the adjacent faces of the packing rings engage the pin, which is in this case anchored in the expansion rings at an angle of 135 deg. from the gap therein. The relative rotation between the primary and secondary packing rings is controlled by pins anchored in the primary packing ring and which are located in the gap of the corresponding secondary ring. The pins are so mounted in the primary rings that the gaps of the secondary rings are at an angle of 90 deg. from one another. These predetermined positions give the best lateral action.

The ring, which is manufactured by Frederick Du Bois Blauvelt, New York City, is designed to take the place of a plurality of piston rings used at present, and to provide a composite ring particularly adaptable for internal-combustion engines having high compression and slow speeds. It is made for cylinders from 5 to 30 in. in diameter.

Ohio reports that millions of tons of coal are on fire on lake port docks from spontaneous combustion indicate that we are reaping one of the fruits of war hurry, says the *Wall Street Journal Straws*. An industrial coal expert explains that during the war everything was coal, the good, bad and worse, and as such was dumped indiscriminately at lake ports. In this way much coal with high sulphur content was dumped in big piles. The action of water on the sulphur in the coal piles forms crude sulphuric acid. This, in turn, generates heat and causes combustion. Water, except in great quantity, is useless in fighting coal fires. Going to the heart with a steam shovel alone settles the question. Apprehension is expressed that the lake coal situation, owing to the big tonnage that is involved, may prove to be extremely troublesome as well as costly.

PLANT OF THE *Hotel Traymore*

JUST what does it require in light, heat and power to care for the necessities, conveniences and comforts of the guests of this beautifully imposing palace in America's greatest all-year playground, Atlantic City, N. J.? The Traymore is, in general, patterned after a castle on the Killarney Lakes of Ireland. There is a total of 900 rooms, including 700 guest rooms with baths; 1400 guests could be conveniently accommodated, though 1100 is the usual maximum. One travels far before seeing such impressive architecture.

The hotel stands on the beach. The engine room is on the ground level, the boiler room being 4 ft. below sea level. There are six 200-hp. water-tube boilers in three batteries. These are handfired and carry 125 lb. pressure with no superheat. Buckwheat No. 1, 50 per cent., and Lykens Valley buckwheat No. 2, 50 per cent., is used at present.

The boiler-furnace walls and boiler tops are covered with 4½-in. insulating brick and plaster. The flue-gas temperature is plotted by a recording pyrometer, the CO_2 is recorded, and control of combustion is guided in part by combined draft gages, known widely as a "boiler efficiency meter." The firemen are negroes trained by the watch engineers. Typical CO_2 charts show that combustion results usual in this plant are equal to those had in large industrial and central power plants where high-set boilers with stokers are the rule. The heat for the whole hotel—that is, for the light, power, heating, steam for the laundry and the kitchen—comes, of course, originally from the coal. The coal consumption in winter averages about 800 tons per month and in summer about 600 tons.

Up to this writing the water has not been accurately metered, and no scales, automatic or otherwise, are regularly used, therefore accurate data upon which to determine the boiler performance are not available. Coal scales and a water meter likely will soon be installed. Roughly, however, about 8.5 lb. of water per pound of coal as fired was the average evaporation during 1918. The combustion chambers and tubes are cleaned monthly.

The stack, or natural, draft is 0.75 in. in the furnace. For burning the mixture of Nos. 1 and 2 buckwheat coal, a steam blower is used.

No city water is used in the hotel. Fresh water is had from two wells, each 850 ft. deep, the water being raised by air lift with 80 lb. pressure on the wells and 100 lb. on the supply tank. The air is compressed in two-stage compressors shown in Fig. 2. Air for the operation of the thermostatically controlled valves in the heating system is furnished from the main supply tank mentioned, through a reducing valve. For lighting and power one 125-kw. and two 250-kw. Corliss engine-driven direct-current generators are used. The power voltage is 220, the lighting

CHIEF ENGINEER GEORGE W. ARMITAGE

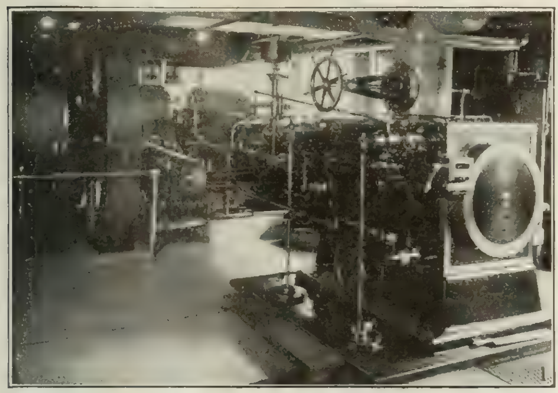
voltage 110, motor-generator balancer sets being used. The average load through the day is 500 amperes, 1100 to 1200 amperes at night, 220 volts. One of the 250-kw. generating sets is shown in Fig. 2. Tests conducted on these units gave the following results:

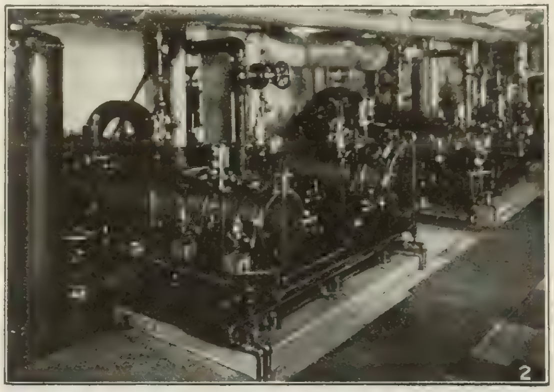
Indicated horsepower at 1060 amp., 225 volts	356.85
Friction load, horsepower	15.7
Efficiency of engine and generator, per cent	86.6
Steam consumption 1 horsepower-hour, lb	19.0
Pressure, lb. gage	115.0
Back pressure, lb. gage	Atmospheric
Speed, r.p.m.	112.0
Clearance, per cent. estimated	3.0

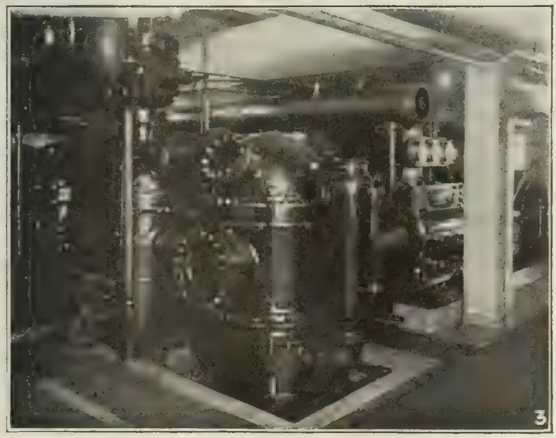
The switchboard is shown in Fig. 4.

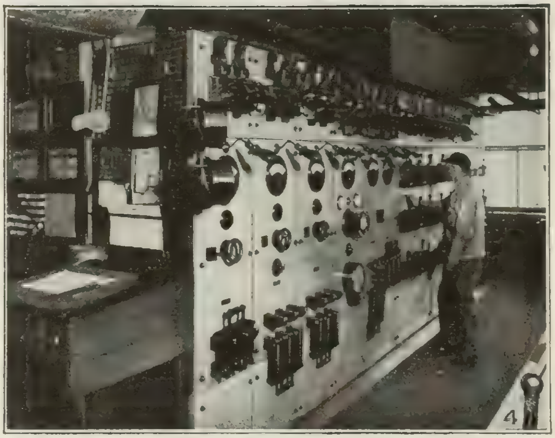
All large elevators are of the hydraulic plunger type. There are ten for passenger service, one for the kitchen and one chair lift. Two passenger cars go to the top floor, the length of the 6½-in. plunger on each being 225 ft.; the other passenger cars have 6½-in. plungers, each 180 ft. long. The service cars have 5½-in. plungers. The operating pressure is 160 lb. and the pilot pressure is the same. There are eight counterbalance cables to each car.

The high-duty, outside-packed elevator pump is driven by a three-cylinder compound engine—one 18-in. diameter high-pressure cylinder, each low-pressure 24-in., stroke 24-in. The steam consumption per indicated horsepower was 19.9 lb. on tests under the same operating conditions given for the engine of the generating set. This pump was specially designed for the service at hand; a view of the water-end is shown in Fig. 3.









FIGS. 1 TO 4. VIEWS IN THE ENGINE ROOM, HOTEL TRAYMORE

Fig. 1—One of the 250-kw. Corliss engine generating sets. Fig. 2—Showing the two-stage air compressors. Fig. 3—View of the water end of the high-duty elevator pump. Fig. 4—The switch board.

The plungers are 11¼ in. in diameter, the chambers being of the large pot type with 5½-in. diameter soft-rubber valves.

Two relay pumps are used, each 18 and 28 x 14 x 24-in. of the American Pump Co. type.

Exhaust steam is the medium used for heating the building. There is a total of 65,240 sq.ft. of radiating surface, chiefly in 1600 radiators; to distribute the steam 220 risers are used. For a time after the opening of the hotel 15-in. vacuum was maintained in the returns owing to a rise and fall in several of the lines. This rise has been eliminated by the chief engineer and now but 6-in. vacuum is required. One with experience with large heating systems appreciates how such a reduction has decreased air leakage into the systems and other troubles arising from carrying a high vacuum on a heating system.

The steam supply to the radiators is at the top, through a vapor valve. Exhaust steam does not issue from the hotel except on some days during July and August, all of it being demanded for use within the building. The laundry uses considerable. In addition to exhaust steam, the laundry uses some live steam supplied to it through a 4-in. pipe. Worth-while reduction in the use of live steam by the laundry has been effected by the removal of several small live-steam pipes formerly used to heat water in open tanks. Heedless use of this steam resulted in much waste of it. The water is now heated in a tank under control of the engineers. For refrigeration, ice making and cooling drinking water two horizontal double-acting ammonia compressors of 25 tons each are installed.

A total of 54 boxes are cooled, and about 5 tons of ice is pulled daily. There is can capacity for 13.5 tons in 100-lb. cans. The drinking water is maintained at 40 deg. F. Double-pipe condensers are provided. The circulating water for use in these condensers is taken from the artesian wells, to which it is returned after passing through the condenser.

The vacuum cleaning machines, of which there are two, are of the Palm inclosed horizontal type, each driven by a 10-hp. motor. Each has capacity for handling 800 cu.ft. of free air per minute.

The visitor to this plant is impressed with the unusually smooth operation of the equipment. This is vitally essential to the success of a hotel power plant. Though practically all of the machinery in the Traymore's plant is reciprocating, there is such a marked absence of sound from it, that, standing near the entrance to the engine room, only the initiated ear would know it was there by the intermittent hiss of water rushing through the hydraulic relief valve of the elevator pump.

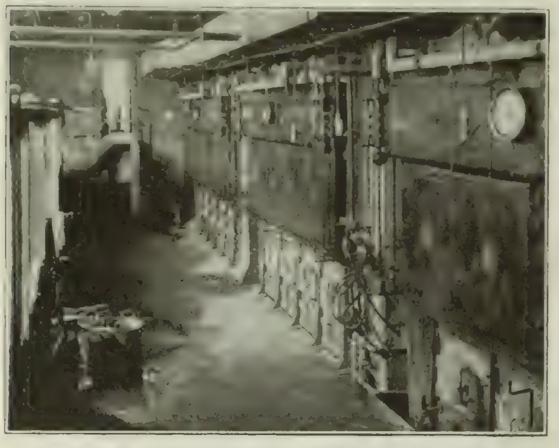


FIG. 5. BOILER ROOM, HOTEL TRAYMORE

The concrete floor of the plant is covered with a well-known preparation. The writer was impressed by the absence of dust from the floor and with absence of oil around the pans under the valve gear of the Corliss engines.

Price & McLanahan, of Philadelphia, were the architects; the heating system was installed by William M. Anderson, Philadelphia. The engines, elevator pumps, elevators, tanks, etc., were designed and built by the Robert Wetherill Co., Chester, Penn. George W. Armitage is chief engineer.

Shipment of Power-Plant Equipment

By M. A. Saller

While the average manufacturer or purchaser of power apparatus is concerned with specifications, guarantees, details of construction, etc., it frequently happens that little attention is given to proper shipments and packing.

Probably the first point of importance is making shipment and delivery on scheduled time, especially on new construction work, where it is necessary to place one piece of equipment after another, and where frequently one appliance cannot be put in position until another line of equipment is installed. Delay may hold up dependent work, cause a change of plans and scaffolding at considerable extra expense or make it necessary to leave unfinished some parts of the building walls in order to admit the delayed equipment.

Freight shipments and routings are also important. If a plant is situated on a railroad siding, where facilities are available for removing the equipment from cars with cranes, the shipments should be sent over that particular railroad; if routed over another line it will be necessary to pay transfer charges or haul the equipment from another freight station.

The shipment of heavy machinery in high-sided gondolas is a source of embarrassment and expense when the crane capacity is not available for lifting the material vertically from the cars. Shippers of heavy machinery should use flat cars unless it is known that the purchaser can handle the material satisfactorily from a high-sided car.

The shipper should make sure that the apparatus is firmly attached to the car so that it cannot work loose in transit. This will avoid broken or bent parts due to shifting of the apparatus.

Sometimes the manufacturer will forward apparatus which is not complete; that is, make a partial shipment without notifying the customer specifically just what has gone forward and what is to follow. Confusion and delay are then bound to occur when the purchaser begins to erect the apparatus and finds certain parts missing. When partial shipments are made the manufacturer in every case should notify the customer as to what parts are missing and when they will follow. The purchaser should also be notified when shipment is made, over what routing, etc., but in many cases the manufacturer is remiss on these details.

It is rarely possible to ship power-plant equipment complete and erected. In most cases the fittings and small parts are packed in crates or boxes accompanying the main unit. Each box, crate or detached part should be marked with the proper order numbers and identifications so that the box or part can be identified even if it becomes detached from the main shipment en route. Some manufacturers follow the excellent policy of making up a detailed packing list showing the number of each box or package with an itemized list of the parts or fittings contained therein.

It is a notorious fact among power-plant equipment erectors that the detailed directions and instructions for the erection and installation of the equipment often never reach the actual operating force, but are retained in office files or in the storeroom. Manufacturers should arrange to send complete directions by mail to the purchaser, and also include such directions with the actual shipment so that they are available to the erecting men on the ground in case the instructions previously sent do not reach them.

Innumerable complaints are received by shippers and manufacturers to the effect that parts of shipments, fittings or other items are "short." In a great many of the cases the shortage is the result of oversight or a mistake at the source of the shipment; but experience has shown that oftentimes the reported shortage is due to carelessness or lack of system in unpacking or perhaps to theft. When excelsior is used in packing care must be taken that no small parts are thrown away with the packing material.

Horsepower Requirements of Centrifugal Pumps

By T. M. HEERMANS*

Horsepower requirements as related to motor drive. How to figure it, including the power to lift the water and overcome friction and velocity heads and the allowance made for pump efficiency. Starting torque, types of motor used and motor troubles traceable to the pump.

BEFORE attempting to show why one centrifugal pump needs a 100-hp. and another a 50-hp. motor, or why a squirrel-cage motor is best for some conditions and not for others, it might be well to consider a few fundamental relations as affecting the horsepower required to do pumping work with this kind of pump.

A centrifugal pump raises water by the rotation of a runner in a properly designed casing which is first filled with water, or primed, before pumping can begin. As may be seen in Fig. 1, the runner is mounted centrally in the pump casing and fastened to the shaft which extends out of the casing for connection to the driving motor or engine. When the shaft is rotated, the water in the pump is forced from the center outward by the runner and into the discharge passage, while more water is drawn up into the pump to take the place of that displaced, thereby making the pumping continuous. The energy given the water by the runner is sufficient to raise it to some height and discharge a certain quantity, depending on the speed of the pump, the diameter of the runner and its design. It can be seen, therefore, that work is done by lifting this quantity of water to the given height.

CONSERVATIVE EFFICIENCIES FOR PUMPS OF VARIOUS CAPACITIES

Size of Pump, In.	Normal Capacity, G.P.M.	Efficiency Single-Stage Heads Up to 150 Ft., Per Cent.	Efficiency Multistage Heads Above 150 Ft., Per Cent.
2	100–150	50	45
3	200–350	55	50
4	400–600	60	56
5	650–900	65	62
6	950–1300	70	68
8	1500–1800	72	70
10	2000–3000	75	72
12	3500–4500	76	73
14	5000–6500	77	74
16 and over	....	78	75

The amount of useful work done is known as the water horsepower and is equal to the weight of water lifted a certain number of feet in a definite length of time. Since pump capacity is usually expressed in gallons per minute (g.p.m.), and a gallon of water weighs $8\frac{1}{3}$ lb.,

$$\textit{Work done per minute} = \textit{g.p.m.} \times 8\tfrac{1}{3}\ \textit{lb.} \times \textit{feet head},$$

and as one horsepower is equivalent to lifting 33,000 lb. one foot in one minute, water horsepower,

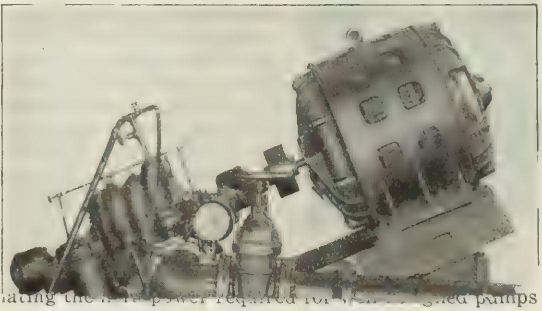
$$W.\ hp. = \frac{g.p.m. \times 8\frac{1}{3} \times \textit{feet head}}{33{,}000} = \frac{g.p.m. \times \textit{feet head}}{3957}$$

In the preceding formulas the head not only consists of the height the water has to be lifted but also includes the head lost by friction in the piping and the head required to make the water flow through the piping at a given rate; that is, the total head equals the static lift plus pipe friction plus velocity head. The driving motor, therefore, to turn the runner at the required speed must be able to develop the water horsepower the pump takes, and in addition there are losses in the pump to be overcome.

Briefly, these losses in the pump are the friction of the water in the casing on the outside of the revolving runner, leakage and other hydraulic losses on the inside of the pump, and bearing and stuffing-box friction. These losses have to be added to the water horsepower to find out the horsepower actually needed to run the pump and the size of motor required for the drive. The ratio of the water horsepower to the actual horsepower required to run the pump gives the pump efficiency, which pump builders have to determine from

a·er becoming partly obstructed or an obstruction lodging in the suction passage on one side, which unbalances the runner. Unequal wear of the runner wearing rings on opposite sides of a double-suction runner or displacement of the runner slightly to one side of the center line of the casing also will cause thrust. In multistage pumps thrust is generally caused by failure or partial failure of the arrangements provided to balance the end thrust. Two pumps taking their suction from the same suction pipe or discharging into the same discharge line, if they are not properly arranged and do not have the right kind of characteristics, can cause trouble by dividing the work unequally, but this and similar questions are outside the scope of this article.

It can be safely stated that a pump should not be bought merely as a pump of a certain size without any



mating the horsepower required for [illegible] pumps operating at suitable speeds against moderate heads.

As an example, in figuring the horsepower required to drive an 8-in. single-stage pump designed to deliver 1500 g.p.m. against a total head of 100 ft., use the formula for water horsepower previously derived and divide the water horsepower by the pump efficiency given in the accompanying table, that is, horsepower required by the pump is:

$$Hp. = \frac{g.p.m. \times \textit{feet head}}{3957} \div \textit{pump efficiency} =$$

$$\frac{1500 \times 100}{3957} \div 0.72 = 52.6$$

As computed in the last paragraph the horsepower is known as the actual figured horsepower required by the pump, but a motor somewhat larger should be selected, say the nearest standard rating, which is 10 to 12 per cent. greater than the brake horsepower figured. In the case worked out, therefore, a 60-hp. motor would be recommended. There are several reasons for giving motors this slight margin of horsepower over that actually figured.

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In the first place the runners of commercial centrifugal pumps cannot be turned out easily to the thousandth of an inch in the cast passages without unduly increasing the cost. Consequently, in fitting pumps with runners for a given condition, the size of the runner openings are made a little large to allow for slight inaccuracies of manufacture and to make sure that the pumps will test out slightly over capacity. This usually is not objectionable to the purchaser, as very few complaints are made because a pump discharges more than the guaranteed quantity, provided the motor is not overloaded. A margin allowed in figuring the motor, therefore, will prevent its being overloaded should the pump be slightly over capacity. It is also true that runners, after being used for some time, may become worn, causing the runner to handle more water, and although this water may not be discharged but merely circulate around inside of the pump, still the load on the motor will be increased.

FIG. 5. BOILER ROOM, HOTEL TRAYMORE

practically all of the machinery in the Traymore's plant s reciprocating, there is such a marked absence of ound from it, that, standing near the entrance to the ngine room, only the initiated ear would know it was here by the intermittent hiss of water rushing through he hydraulic relief valve of the elevator pump.

The concrete floor of the plant is covered with a well-known preparation. The writer was impressed by the bsence of dust from the floor and with absence of oil

Then again, possibly to meet certain conditions, a pump will have what is known as a rising horsepower characteristic, which means that the horsepower does not drop off as the head decreases and the pump delivers more water, but increases with the discharge. With a pump having a rising horsepower characteristic as in chart *A*, Fig. 2, if there is a possibility that it will be operated against lower than rated heads, it should accordingly be connected to a motor large enough to handle the load over the complete pumping range of head without being dangerously overloaded.

Still other pumping units are used in places that are hot, damp or poorly ventilated, and to insure reliable operation the motors will be selected slightly large. Finally, the present trend in rating motors is to give them a maximum rating with very little if any overload capacity. This means that maximum rated motors, particularly for driving pumps, will have to be chosen big enough at the outset, as they would not work safely if overloaded. For all these reasons the usual practice in fitting motors to centrifugal pumps, as previously stated, is to allow 10 per cent. leeway over the horsepower that it is figured will be required.

Besides knowing the size of motor to put on a pump, it is necessary also to know something about the starting requirements of centrifugal pumps and how they affect the selection of the type of motor and also the starting apparatus to be used. Centrifugal pumps are started up quite easily and are generally considered "light starting duty for a motor." Consequently, squirrel-cage motors, and even synchronous motors that do not have much starting torque, can be used to drive centrifugal pumps, but this statement needs a little explanation. The curves of Fig. 2 are typical of the performance characteristics of three different types of centrifugal-pump runners. Chart *A* is for a standard single-stage centrifugal pump fitted with a runner having a rising horsepower characteristic. By slightly changing the runner design, this pump can be made to have a horsepower curve that is practically flat from the point of maximum efficiency on. Chart *B* is representative of the ordinary type of multistage pump with diffusion vanes, and chart *C* shows the characteristics of a single-stage pump with a so-called Francis type runner which is particularly designed so that relatively high pump rotative speeds can be employed for low heads. These curves have been reproduced to show in particular the "shutoff horsepower" of different kinds of pump runners. This is the power required to rotate the pump runner at rated speed in the pump casing when full of water but when no water is allowed to be discharged, as would be the case when the pump is started up with the valve in the discharge from the pump closed. The shutoff horsepower has been indicated as a certain percentage of the horsepower required at the highest point of the curve, which has been taken as 100 per cent.

Slip-ring or shunt-wound direct-current motors will start pumps having the characteristics shown by all three curves, and squirrel-cage motors also have been found capable of starting these pumps, although in the larger sizes and sometimes for pumps having the characteristics shown by chart *C*, squirrel-cage motors will take too much current in starting to be used. Standard synchronous motors will ordinarily start pumps having the characteristics of chart *A*, and develop the necessary torque to pull into synchronism when up to speed, but will have to have specially constructed motors to develop the 50 per cent. of rated horsepower required to pull pumps having the characteristics of chart *B* into synchronism, and cannot be used at all, except by making special arrangements to start pumps having the characteristics shown in chart *C*.

The special arrangement just mentioned is to equip a pump so it can be started up empty and then primed after being brought up to synchronous speed. What is done is to provide some means of lubricating the close clearances in the pump until it can be primed, when the water will provide the lubrication. The necessary arrangements can be made easily on single-stage pumps, but it is rather difficult to fix up the multistage type. For this reason they are seldom started up empty, although clutches are sometimes employed.

All the previous remarks apply to pumps that are started up with a closed valve in the discharge. As a general rule this should be figured on, as otherwise starting conditions will be much worse. It is necessary only to refer to the curves again to see that where no discharge valve is provided, the motor in coming up to speed has also to come up to full horsepower and be thrown on the line at full rating instead of at a fraction of full horsepower. This is not good practice and is bad for the motor even if undue disturbances will not be caused in the line. Instances have been known where the heavy surges of current to start squirrel-cage motors attached to centrifugal pumps without any valve in the discharge have in time loosened up the motor coils.

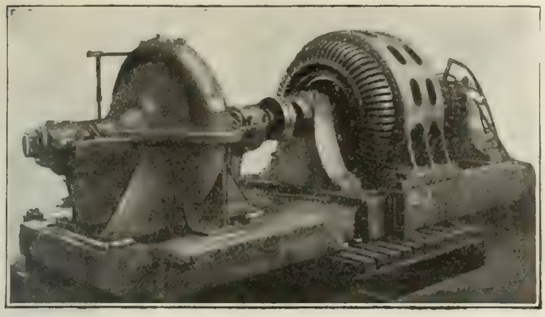


FIG. 3. MOTOR-DRIVEN SINGLE-STAGE 10500-G.P.M. CENTRIFUGAL PUMPING UNIT

Having considered the power required to start and operate centrifugal pumps, brief reference will be made to the kinds of motor used for pump drive. This is a large subject in itself and will be taken up in detail in succeeding articles. Probably the motor most commonly used to drive centrifugal pumps is of the squirrel-cage induction type. This motor, on account of its simplicity and also because the starting duty of a centrifugal pump is not heavy, is used to drive the majority of small and moderate-sized pumps.

In sizes over 150 hp. and in many cases less, the slip-ring induction motor is used instead of the squirrel-cage type, because it takes less current from the line in starting. Also power companies often fix the maximum size of squirrel-cage motor they will allow to be connected to their lines. In still other cases where a system does not have much capacity, throwing a large squirrel-cage motor on the line would cause serious disturbances and possibly a voltage drop that would be enough to prevent the motors coming up to synchronous speed. These cases call for the use of slip-ring motors. This type is used sometimes when a moderate amount of speed control of the pump is required, possibly to maintain a constant pressure with a variable discharge or to maintain a constant discharge with varying heads.

Direct-current motors as well are used where speed variation is required, but for constant-speed service are not used so much as induction motors. Then, too, for moderate heads standard centrifugal pumps ordinarily run at higher than the best direct-current motor speeds. However, relatively high-speed direct-current motors are now being built that can be used as satisfactory pump drives where only direct current is available.

As a fourth kind of pump drive synchronous motors are just beginning to receive deserved attention. Many centrifugal pumps, because they offer a constant steady load, present a fine opportunity for using a large synchronous motor to keep up or correct the power factor of a power system, and by using proper care suitable synchronous motor-driven centrifugal pumps can be often selected.

Before leaving the subject of the horsepower requirements of centrifugal pumps as related to motor drive, possibly it will be well to point out a few troubles that are sometimes encountered with motors and that are traceable to the centrifugal pump. The most common difficulty, which has been mentioned previously, is operating an improperly selected pump at less than the rated head. This will overload the motor and cause it to run hot. Another trouble almost as common is pump and motor out of alignment due to improper erection. This causes vibration and hot bearings and wears out rapidly the coupling bushings. A third trouble sometimes experienced and resulting in hot motor bearings, is when the centrifugal pump develops an end thrust, causing collars on the shaft to rub on the ends of the bearings. End thrust may develop in a single-stage double-suction pump on account of one side of the runner becoming partly obstructed or an obstruction lodging in the suction passage on one side, which unbalances the runner. Unequal wear of the runner wearing rings on opposite sides of a double-suction runner or displacement of the runner slightly to one side of the center line of the casing also will cause thrust. In multistage pumps thrust is generally caused by failure or partial failure of the arrangements provided to balance the end thrust. Two pumps taking their suction from the same suction pipe or discharging into the same discharge line, if they are not properly arranged and do not have the right kind of characteristics, can cause trouble by dividing the work unequally, but this and similar questions are outside the scope of this article.

It can be safely stated that a pump should not be bought merely as a pump of a certain size without any reference to the work it will have to do. In conjunction with the driving motor it should be selected to do certain definite work to the best advantage. It is therefore preferable to buy pumps that have been tested carefully and their characteristics determined, with motors of suitable size to run the pumps under all the conditions that will be met with in service. That is, a pump and the drive should be considered as a unit and selected accordingly.

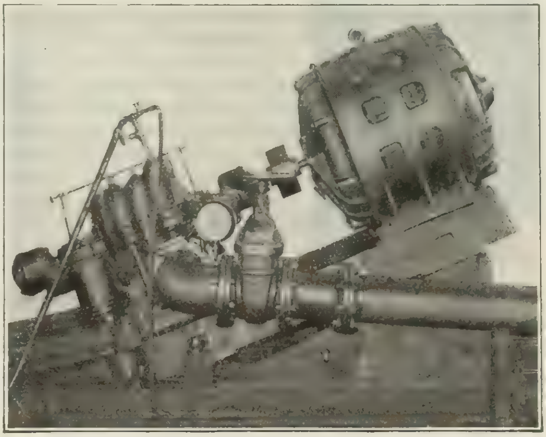


FIG. 4. MOTOR-DRIVEN MULTISTAGE 1800-G.P.M. CENTRIFUGAL PUMPING UNIT

Both motor and pump have combined radial and ball thrust bearings as the unit operates in the inclined position shown.

Outlook for the Heavy-Oil Engine

A Discussion by Engineers Prominent in the Oil-Engine Field Covering Present Practice, Tendencies in Designs and the Commercial Prospects

ECONOMY of the Diesel engine is so much superior to that of any other type of prime mover that it is certain not only to remain in its present field but to attain wider employment. It is particularly suited for locations where coal is expensive and fuel oil cheap, although it may often be used to advantage even where coal is cheap, especially in small plants that do not operate continuously, for the reason that stand-by losses of coal-burning plants are eliminated. In Diesel engines the matter of size has little influence on the economy, and in small electric plants using oil at one dollar per barrel the cost of fuel is only about one-quarter of a cent per kilowatt-hour and in a small flour mill in which Diesels are installed, the cost of fuel per barrel of flour runs about one cent with oil at one dollar per barrel

Diesel engines in electric plants will deliver a kilowatt-hour on three-quarters of a pound of oil, while in the best steam plants (large units) where oil is used as fuel under the boilers, the oil consumption per kilowatt-hour ranges from 1¼ to 1¾ pounds.

C. G. SPRADO

One of the most promising fields for the Diesel engine is marine propulsion, because the weight of fuel to be carried for a given voyage is only about one-third of that required for steam vessels using coal as fuel. This means an increase in cargo space of approximately twenty per cent., a much smaller engine-room crew and a form of fuel that can be much more conveniently handled and stowed than coal or, if desired, the steaming radius of the Diesel ship can be made much greater than is possible with a steam-driven ship without carrying an excessive weight of fuel.

The weight of coal for a steamship, either turbine or reciprocating-engine driven, is practically three times that of fuel required for a Diesel engine of the same power, and even if oil were burned under the boilers on the steam-driven ship, the weight of fuel would be more than double that required for the Diesel-engine ship.

Diesel-driven ships of any size should be fitted with two engines and twin screws as is customary with steam-driven ships, but it is especially necessary for the larger Diesel ships on account of the limitation of the size of engines which it has been found feasible to construct up to this time.

Owing to the high pressures used and the high temperatures developed, the Diesel engine has some limitations as to size and up to the present time has not been built much above 3000 hp., and its development above this power will probably be rather slow, so that at present it can be considered only for plants of moderate size or for large plants where it is desirable, on account of flexibility, to have several units.

While the Diesel engine has unequaled economy, its reputation has suffered in some instances from being used under unsuitable conditions, but more especially by unskillful handling. Overenthusiastic advocates of the Diesel engine have injured its reputation by leading purchasers to believe that the machine was "fool-proof" and required no operating skill; but as a matter of fact, in return for its very high economy the Diesel engine demands a certain amount of attention (such as grinding valves, etc.) at the right time, and there are instances where absolutely duplicate installations have either been highly successful or practical failures, dependent entirely on the skill of the operating crew.

The Diesel engine is practically a "maximum rated" machine, for its power is limited by the volume of air compressed in the main cylinders, as the amount of oxygen present determines the quantity of oil that can be given perfect combustion. It can readily be seen that on this account Diesel engines are limited to small overload capacity and that for comparatively short periods, but they will operate with relatively high economy on lighter than maximum loads.

Like all moderate-speed internal-combustion engines, the Diesel has a relatively high first cost per brake horsepower, and in order to offset this there has been a tendency among builders to over-rate their engines both as to capacity and speed; while this may do no harm on fluctuating loads, it is sure to give unsatisfactory operating results on continuous heavy loads such as marine work, pumping, flour mills, etc., owing to overheating, carbon from incomplete combustion, etc.

In brief, it may be said that the Diesel engine has the limitations of all internal-combustion engines, which, however, are not serious and are now well understood; and because of its superior economy and ability to operate on any kind of liquid fuel, it may be confidently predicted that it will find a rapidly widening field and will continue to be used so long as fuel oil is obtainable at any reasonable cost. C. G. SPRADO,

Engineer in Charge of Gas and Oil Engines,
Allis-Chalmers Manufacturing Co.
Milwaukee, Wis.

DR. DIESEL secured his first patent in 1893, and the first successful engine was put in operation in 1897 in a match factory in Germany. During the duration of the original Diesel patents the use of this invention was mostly limited to one licensee in each of the principal countries, and the late Adolphus Busch, of St. Louis, Mo., induced by the late Colonel Meier, obtained the sole right for this country. When the original patents had expired, approximately 50,000 hp. in Diesels were in operation in this country, and as by this time their economic superiority had been proved, a large number of manufacturers here, and still more abroad, took up the manufacture of this engine.

It has often been asked why it is that the European countries have developed this engine on a much larger scale than this country has done it, in spite of the fact that oil here is so much cheaper than in Europe. Some of the reasons are the following: Firstly, coal is much cheaper in this country than in Europe; secondly, the steam engine is much cheaper here than in Europe, but the Diesel engine is not and will never be, as it is an engine of high-class material and skilled workmanship; thirdly, in America the question of first cost is more important than it is in Europe where economic operation and the greatest possible economic production are the leading and cogent features in industry. However, our easy attitude in this direction has been changed more or less through this war, and we also will in the future be compelled to watch the economic side if we want to compete in the world market, particularly at the present rate of labor.

A great deal of resourceful study and work of this kind is bound to set in. Actual figures of operation of plants in Texas, Arizona and other Southern States where Diesel engines were substituted for steam plants showed the following saving: A barrel of flour was produced at 1½ to 1¾ cents for fuel oil, compared with 8 to 10 cents and more for steam; and water pumped at from 7 to 9 gal. of fuel oil per 100 water hp. against 50 to 60 gal. for steam plants. Similar remarkable results have been obtained in ice and electric-power plants and with marine Diesels. The quoted examples apply, of course, in the same measure to other parts of the country. Wherever we have today an oil-fired boiler, by putting in a Diesel engine only one-third to one-fifth of the fuel will be required. This fact is at the same time an answer to the fuel-oil supply of the future, since we can on this basis more than triple the capacity of our prime movers before we reach again the demand of fuel under present conditions.

At the present time we are most interested in the question as to whether the Diesel engine is still in its experimental stage and if there is enough experience available to guarantee success to the manufacturer when he enters this new field. The latter certainly must be answered in the affirmative. The next question is, which type is the one to be preferred? The writer claims that this can today be answered definitely on the basis of failures or final success in actual operation. It is known which types have failed and which have met with indisputable success and why. Of course there still remain questions to be solved, but as a whole it can be said that competent Diesel engineers have settled down to certain generally recognized standards which must be followed if a successful Diesel engine is expected. This applies to design, construction and operation.

A few items as to the design, which have become recognized elements, may be enumerated. The trunk piston has given a very satisfactory service up to about 16 in. in diameter; for larger sizes most of the leading manufacturers have adopted the crosshead type. With about this size, or starting perhaps with 20 in. in diameter, water cooling of the piston is required. The elements that demand the most attention as to design are a rigid and heavy baseplate, with well-supported bearings, and, as to design and material, it is the piston, cylinder liner and cylinder head.

In the writer's opinion the future development of the oil engine in this country will see, up to 200 or 300 hp., at the most, the more cheaply constructed hot-bulb engine (not Diesel) prevailing on the market; from there up to 2000 or 3000 hp. the single-acting four-cycle engine, and from 2000 hp. upward the double-acting two-cycle type.

The single-acting two-cycle stationary engine in larger units has met so far with little success except perhaps under particular conditions, where the full rated capacity has never been called upon or in the most during a very short interval at the time of peak load. Judging by single-acting two-cycle engines which the writer has watched in operation, the bearing troubles —that is, the continuous one-sided pressure—seem to be the most serious. At the present time on the test stand of one of our largest companies of the world a single-acting marine Diesel of about 2600 hp. is being submitted to the severest test in order to study these various questions, and we engineers must congratulate any company that is willing to do such pioneer work and we may hope that this engine will show up in actual sea operation better than other European types of this class have done. It has been reported that Sulzer Bros., of Switzerland, have recently had great success with this type of engine, but it still remains to be seen how they will stand up in continuous operation.

H. SCHRECK

Another novelty in this line is the solid-injection engine, which type is still too new for one to express any definite opinion one way or the other. It only may be said that the tests, so far carried on with it, entitle one to expect a great future for it, which is all the more to be hoped, as it simplifies the Diesel and makes it a cheaper engine.

It might be of interest to mention the limit that has been reached so far as to size. Sulzer Bros. have built stationary two-cycle engines of about 4000 hp. each, with cylinders of 29.92-in. bore; the "Bullaren," built in Sweden, has two six-cylinder four-cycle engines of 29⅛-in. bore; the "Glenapp," built in England, has two eight-cylinder four-cycle engines of 29½-in. bore; and the Engine Works of Nuremberg, Germany, have probably by this time finished and delivered their three-cylinder double-acting two-cycle engine of 31½-in. bore.

From these figures it would seem that about 30-in. cylinder bore is the limit to which one can go safely. Going to a still larger cylinder bore increases the difficulty of transmitting sufficiently the excessive heat through the cylinder walls, and with a larger size we are going into the experimental region of the Diesel engine. Schneider & Cie., of France, have been running for some time on the test stand a single-cylinder two-cycle unit of 39⅜-in. bore which is developing 1200 hp. in this one cylinder. As far as the construction of larger engines in this country is concerned, it can be stated that only two companies have under construction four-cycle engines whose cylinders are of 28 and 30-in. bore, respectively, which is about 250 to 300 hp. per cylinder.

H. SCHRECK,
Chief Engineer Diesel Engine Department,
Whittelsey & Whittelsey, Naval Architects.
New York City.

THE first internal-combustion engine was designed to use gas for fuel, and 95 per cent. of the engines of today are gas engines trying to run successfully on liquid fuel more or less imperfectly gasified by atomization and heat.

So used to gas engines are both the builders and the ultimate users that a change from this type of prime mover to a type using fuel which will not gasify by induction seems such a radical innovation and a herculean task that builders of automotive engines hesitate to start such a departure, yet practically every concern building large gas engines is getting into the heavy-oil type.

C. E. SARGENT

But the advantages of engines using fuel or crude oil as found in nature over that type of engine which must have volatile hydrocarbon fuels to work successfully, are so great, even if the price of fuels were not taken into consideration, that in the writer's opinion self-igniting constant-compression heavy-oil engines even for automotive purposes will become standard and a universally used type much sooner than the most optimistic expect. While large fuel-oil engines have been in successful operation for years, some running continuously for six months at a time without a shutdown, builders of automobile engines, whose output exceeds the output of the manufacturers of all other prime movers, are still making the original gas engine with its low, inefficient compression and complicated ignition system, until now the price of volatile hydrocarbons has increased 600 per cent. On account of the variable disassociation characteristics of the volatile fuels now obtained by intensive distillation, explosion pressures in gas engines often reach twice the maximum pressure obtained in the cylinder of a high-compression fuel-oil engine, so the question of weight and strength is in a sense automatically solved by the light-weight variable-compression engines withstanding these excessive pressures.

As efficiency increases with compression in any internal-combustion engine and as the compression of gas engines which compress a combustible mixture is limited by the critical pressure of preignition, the heavy-oil engine compressing pure air from five to eight times higher, naturally delivers a horsepower on a smaller number of heat units per hour.

The present standard automotive gas engine, of which millions are in operation every day of the year on account of a limited compression must have an intricate, complex (and often defective) ignition system to start the inflammation, while heavy-oil engines with high compression automatically provide the heat for ignition.

While the ordinary gas engine at full load is about two-thirds as efficient as the heavy-oil type, yet the method of controlling the speed and load by varying the quantities of the constant mixture induced, is as inefficient as throttling a steam engine to reduce the mean effective pressure.

Constant-compression engines using a liquid fuel the quantity of which varies with the load will eventually supersede variable-compression gas engines with complicated gas-making attachments if thermal efficiency is taken into consideration and simplicity and reliability are to be desired.

The company with which the writer is connected is building one- to six-cylinder heavy-oil engines from ten to one thousand horsepower and expects eventually to furnish heavy-oil engines for trucks, tractors and automobiles which will fit in standard chassis, as well as larger engines for all purposes of the most exacting conditions, including reversing marine and power-plant units.

C. E. Sargent,
Chief Engineer, Midwest Engine Co.
Indianapolis, Ind.

AT THE present time probably all reputable manufacturers of stationary oil engines have sufficient orders on their books to keep them busy for six months or a year to come. This great volume of business at the present time is to some extent due to the fact that many large users of oil engines for one reason or another did not make the usual enlargements to their equipment during the period of the war, and now that labor is more plentiful the increase in their business has necessitated this action. The outlook for future oil-engine business is encouraging and may be still more so as prices of raw materials decrease. As long as skilled labor demands the high rates now existing, the price of the finished oil engine cannot be much decreased.

Great developments and improvements have been effected in oil engines in the last ten or fifteen years, with regard to reliability in operation and also as to economy of fuel. The guarantee of 0.9 lb. of fuel made fifteen years ago is now reduced to 0.45 or ½ lb. per b.hp. per hour, which is made by many concerns both with the hot-surface type and Diesel oil engines. While the earlier engines could burn only the lighter fuels, today the guarantees already mentioned are made when using any fuel or crude oil produced in the United States or Mexico. Many oil engines have operated continuously day and night for six and eight months at full load, which is a sure proof of their reliability.

In the larger sizes, say from 500 to 1000 hp., where a highly skilled attendant can be in charge, the full Diesel type of engine has many advantages and probably will be favorably considered by prospective purchasers. In sizes, say, from 25 to 500 hp., the hot-surface type, with its lower range of pressures and greater simplicity of construction, will find favor. For land installations, except where local conditions such as water and relative cost of fuels favor the oil engine, plants of over 1000 hp. may find competition of the steam turbine not inconsiderable.

The oil engine, on account of its high first cost, is essentially a prime mover which shows to the greatest advantage when operating with a maximum horsepower-hour output per year. It is also supreme in positions where only a bad quality of water, unsuitable for boiler use, is available, and its economy is most prominently set forth where all fuels are at a high cost. For land purposes the horizontal type, on account of its greater accessibility for inspection and repairs, is most favored. The vertical type, for marine installations or for places where floor space is restricted and where sufficient headroom is also available, is employed.

There is a tendency to develop "solid fuel" injection with some Diesel types, thus eliminating the high-pressure air and three-stage air compressor. In the hot-surface type the tendency of improvement which the company that the writer is connected with has followed is the production of an oil engine having a high efficiency, equal to that of the Diesel, but with comparatively low compression, and also, of course, with "solid fuel" injection. A. H. GOLDINGHAM,

Mechanical Engineer, De La Vergne Machine Co.
New York City.

Reversing Field Connections of Compound Generator

By B. A. Briggs

When the field coils of a generator are connected so that their magnetomotive force opposes that of the residual magnetism in the polepieces, the machine cannot build up its voltage. Not infrequently the statement is made that the remedy for this condition is to "cross the field connections." In a shunt machine this can generally be easily done, and as far as the shunt winding in a compound machine is concerned the foregoing is always true. But in the compound generator, to keep the series winding the same polarity as the shunt, the leads of the former must also be crossed if this is possible. However, if the machine is of 100-kw. capacity or above, it not infrequently happens that the series-field leads are heavy copper bars brought to terminals, as shown in Fig. 1, which makes it impossible to cross these leads.

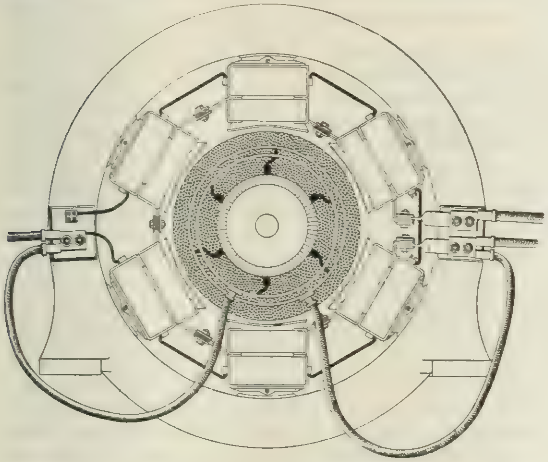


FIG. 1. DIRECT-CURRENT GENERATOR SHOWING NORMAL POSITION OF THE BRUSHES

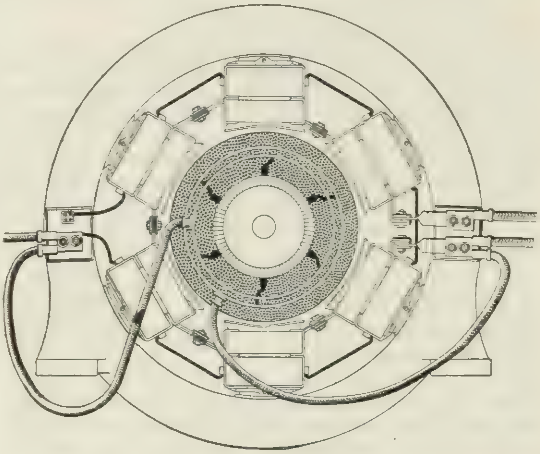


FIG. 2. DIRECT-CURRENT GENERATOR BRUSHES SHIFTED TO REVERSE THE POLARITY

If it is necessary to cross the field connections for the machine to build up, the shunt connections can be crossed and the generator will come up to voltage, but if the field windings are in opposition when the load is thrown on, the voltage will decrease very rapidly as the load increases, owing to the demagnetizing effects of the series-field winding.

It may be possible to cross the armature connection instead of the field. If this can be done, the machine will come up to voltage and the field windings will have the correct polarity. But at the best this generally results in a bad arrangement of the leads around the brush gear, and in many cases the armature leads cannot be crossed.

The best solution of the problem is obtained by shifting the brushes from one neutral position to the next, which means that the brushes will be shifted 90 deg. on a four-pole machine, 60 deg. on a six-pole machine, etc. A comparison of Figs. 1 and 2 will make clear this idea. The brushes in Fig. 2 have been shifted clockwise around the commutator 60 deg. from that in Fig. 1. This will reverse the current through the field windings of Fig. 2 and is the equivalent of crossing the leads of both field windings in Fig. 1.

In a plant where the generator had been moved from one location to another, difficulty was experienced in getting the machine into service. An electrician was called in and found that the generator would come up to full voltage, but that when the load was thrown on the voltage dropped about fifty volts, indicating that the shunt and series-field windings were in opposition. The first solution suggested was to cross the series-winding leads. However, this could not be done as they were made of copper bars, as in the figures, and it was not until after considerable effort that the proper solution was discovered. This was to shift the brushes from one neutral to the next, which left the machine so that it could not build up. Then by crossing the shunt-field leads the machine came up to voltage with the field winding the correct polarity and was put into service without any further trouble.

The cause of the difficulty was that the machine had been dismantled to move it and when reassembled the brushes had been shifted around the commutator the space between two adjacent sets of brushes. When this was done, the machine would not build up; then, to remedy this, the shunt-field winding was crossed, which allowed the generator to come up to voltage but left the field windings in opposition. No doubt the trouble would have been rectified by crossing the series-field lead, if this could have been done, without the true cause even being discovered, but in this case the heavy copper-bar terminals prevented applying this remedy.

The water removed from crude oil by electrical dehydration is of considerable value, for much of it is of such character as to be available for boiler feed.

Operation at Holtwood

RECORD KEEPING FORMS and FOLLOW-UPS

By

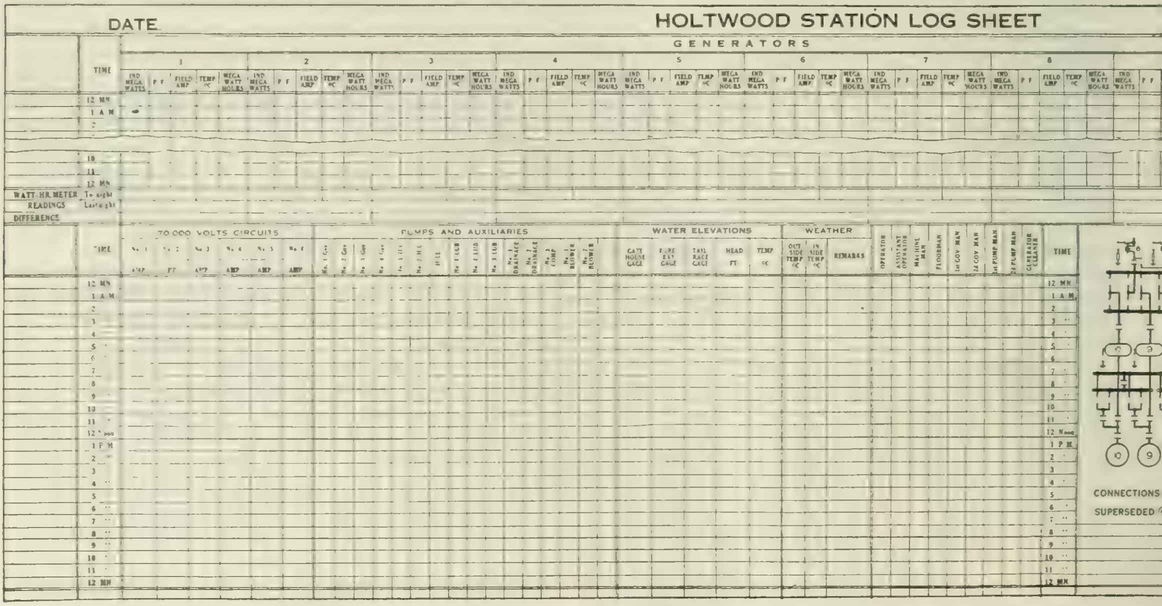
Charles H. Bromley

Describes some of the principal record forms used at Holtwood. It is likely that many engineers will find suggestions of value in this description of the Holtwood record forms.

COPE of the Holtwood Records—The purpose of record keeping at Holtwood is to have before the chief operator a complete record of operation; of cleaning and inspection of all equipment, hydraulic and electrical; of maintenance, that is, repairs done and to be done; of troubles and interruptions; of the estimated and actual river flow, together with conditions of tied-in steam reserve stations and of load demands to facilitate load dispatching. While the reports, charts and follow-up forms are numerous, their use is made convenient by having the much-used forms—as for example, the electrical cleaning progress sheet and the electrical and hydraulic maintenance progress charts—mounted in glass-front cases on the wall. All reports, records and charts are bound in loose-leaf books and kept in metal filing cabinets in the chief operator's office, where they are often referred to.

The large hydro-electric station of the Pennsylvania Water and Power Co. is at Holtwood, on the Susquehanna River about twenty-five miles from Lancaster, Penn., and about forty miles in an air line from Baltimore, Md. The power house and dam are of concrete construction, the dam being 2370 ft. long and 53 ft. high, with a base width of 65 ft. The capacity of the station is 118,500 hp. in eight units, five of 13,500 hp. each and three of 17,000 hp. each. Electricity is generated at 11,000 volts and transmitted at 70,000 volts. For further construction details see article by the author, "Power" May 13, 1913.

The Station Log Sheet—The daily report or station log, Fig. 1, will, upon studying it a little, be seen to be thorough yet not burdened with unnecessary items. The main electrical-connections diagrams on the log sheet, one diagram for each watch, is, so far as the writer knows, original with Holtwood. The operator going off watch indicates in red ink on the diagram what oil switches and other connections are closed or open. In the event of disturbances or interruptions the inked-in connections have shown themselves of value in settling disputes, which at times arise.



DATE

HOLTWOOD STATION LOG SHEET

		GENERATORS																			
	TIME	1					2					3					4				
		IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS	IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS	IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS	IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS
	12 MN																				
	1 A M																				
	2																				
	10																				
	11																				
	12 MN																				
WATT-HR METER	To night																				
READINGS	Last night																				
DIFFERENCE																					

		GENERATORS																					
	TIME	5					6					7					8						
		IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS	IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS	IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS	IND MEGA WATTS	P F	FIELD AMP	TEMP °C	MEGA WATT HOURS	IND MEGA WATTS	P F
	12 MN																						
	1 A M																						
	2																						
	10																						
	11																						
	12 MN																						
WATT-HR METER	To night																						
READINGS	Last night																						
DIFFERENCE																							

		70,000 VOLTS CIRCUITS						PUMPS AND AUXILIARIES														
	TIME	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 1 Gov	No. 2 Gov	No. 3 Gov	No. 4 Gov	No. 1 H C	No. 2 H C	[illegible]	No. 1 LUB	No. 2 LUB	No. 3 LUB	No. 1 DRAINAGE	No. 2 DRAINAGE	No. 3 COMP	No. 1 BLOWER	No. 2 BLOWER
		AMP	AMP	AMP	AMP	AMP	AMP															
	12 MN																					
	1 A M																					
	2																					
	3																					
	4																					
	5																					
	6																					
	7																					
	8																					
	9																					
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	11																					
	12 Noon																					
	1 P M																					
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	4																					
	5																					
	6																					
	7																					
	8																					
	9																					
	10																					
	11																					
	12 MN																					

WATER ELEVATIONS						WEATHER												
	GATE HOUSE GAGE	FORE BAY GAGE	TAIL RACE GAGE	HEAD FT	TEMP °C	OUT SIDE TEMP °C	IN SIDE TEMP °C	REMARKS	OPERATOR	ASSISTANT OPERATOR	MACHINE MAN	FLOORMAN	1st GOV MAN	2d GOV MAN	1st PUMP MAN	2d PUMP MAN	GENERATOR CLEANER	TIME
																		12 MN
																		1 A M
																		2
																		3
																		4
																		5
																		6
																		7
																		8
																		9
																		10
																		11
																		12 Noon
																		1 P M
																		2
																		3
																		4
																		5
																		6
																		7
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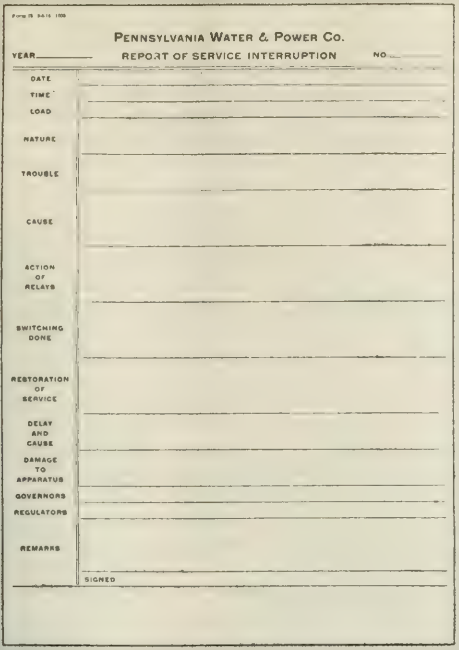
																		9
																		10
																		11
																		12 MN

FIG. 1. FACSIMILE OF THE DAILY LOG SHEET USED IN THE HOLTWOOD



PENNSYLVANIA WATER & POWER CO.

YEAR ______ REPORT OF SERVICE INTERRUPTION NO ______

DATE

TIME

LOAD

NATURE

TROUBLE

CAUSE

ACTION OF RELAYS

SWITCHING DONE

RESTORATION OF SERVICE

DELAY AND CAUSE

DAMAGE TO APPARATUS

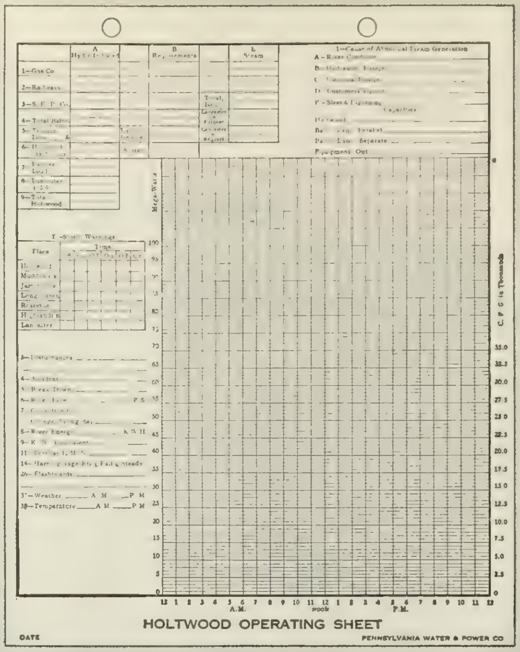
GOVERNORS

REGULATORS

REMARKS

SIGNED

FIG. 2. SERVICE INTERRUPTION REPORT



Mega-Watts

C. F. S. in Thousands

A.M. Noon P.M.

HOLTWOOD OPERATING SHEET

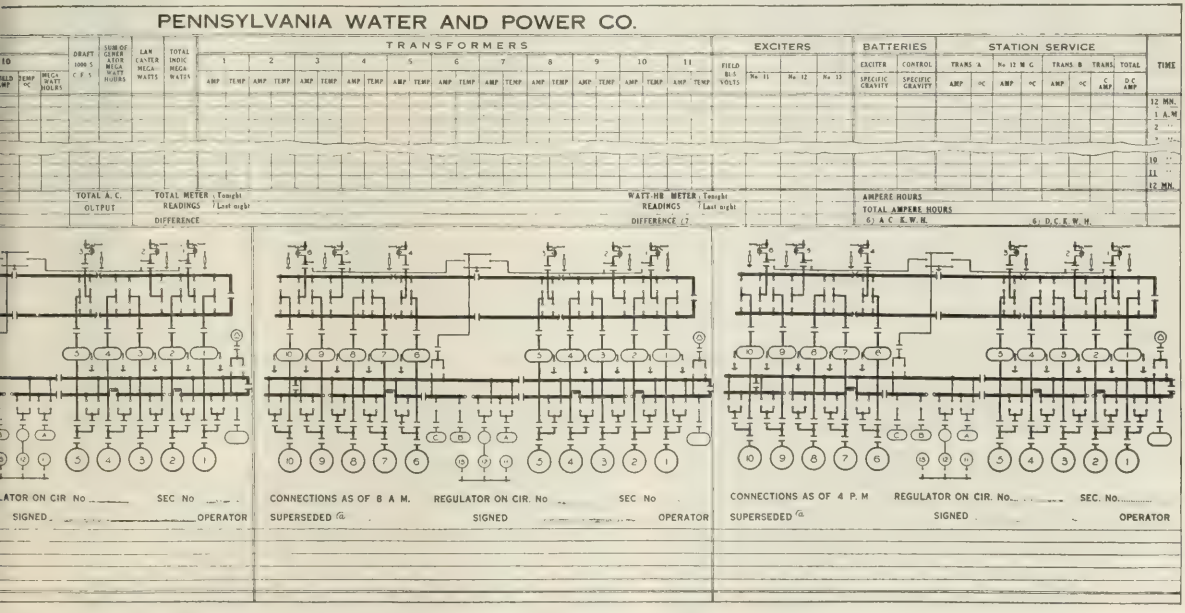
DATE

PENNSYLVANIA WATER & POWER CO

FIG. 3. DETACHABLE END OF THE DAILY LOG SHEET

Notice that the megawatts instead of watts are entered on the sheet. This is done to save writing in a great number of ciphers each day. The switchboard operators and machinemen will tell you how they appreciate the use of "megawatts."

The right-hand end of the log sheet, shown in Fig. 3, is detachable and punched for insertion in the filebook. The load curve and the curve of the power-house draft, as computed hourly from the turbine-efficiency charts by the operator, are plotted on the sectioned part of the sheet; the time that each main unit is in service is indicated by lines at the top of the sectioned portion drawn against hours. The electrical transmission system covers a wide area, and much of it is in a hilly



PENNSYLVANIA WATER AND POWER CO.

10			DRAFT 1000 S C F S	SUM OF GENERATOR MEGA WATT HOURS	LANCASTER MEGA WATTS	TOTAL INDIC MEGA WATTS	TRANSFORMERS																						EXCITERS				BATTERIES		STATION SERVICE								TIME
							1		2		3		4		5		6		7		8		9		10		11		FIELD BUS VOLTS				EXCITER	CONTROL	TRANS A		No 12 M G		TRANS B		TRANS	TOTAL	
ELD MP	TEMP °C	MEGA WATT HOURS					AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP	AMP	TEMP		No 11	No 12	No 13	SPECIFIC GRAVITY	SPECIFIC GRAVITY	AMP	°C	AMP	°C	AMP	°C	C AMP	D C AMP	
																																											12 MN.
																																											1 A.M.
																																											2 "
																																											10 "
																																											11 "
																																											12 MN.

TOTAL A. C. OUTPUT

TOTAL METER READINGS Tonight / Last night

DIFFERENCE

WATT-HR METER READINGS Tonight / Last night

DIFFERENCE (7

AMPERE HOURS

TOTAL AMPERE HOURS

6) A C K.W.H.

6) D.C.K.W.H.

ATOR ON CIR No ______ SEC No ______

SIGNED ______ OPERATOR

CONNECTIONS AS OF 8 A. M. REGULATOR ON CIR. No ______ SEC No ______

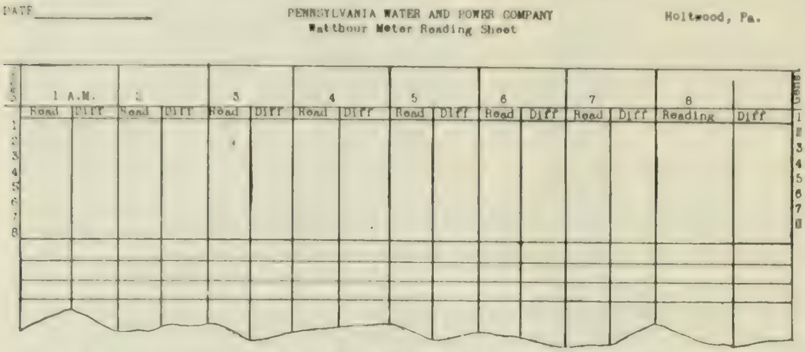
SUPERSEDED @ ______ SIGNED ______ OPERATOR

CONNECTIONS AS OF 4 P. M REGULATOR ON CIR. No ______ SEC. No ______

SUPERSEDED @ ______ SIGNED ______ OPERATOR

STATION. SEE FIG. 3 FOR THE DETACHABLE END OF THE SHEET country where electrical storms sometimes become violent. Whether at Holtwood or at the various substations, steam stations or along the transmission right-of-way, sleet and storm warnings are immediately reported to Holtwood.

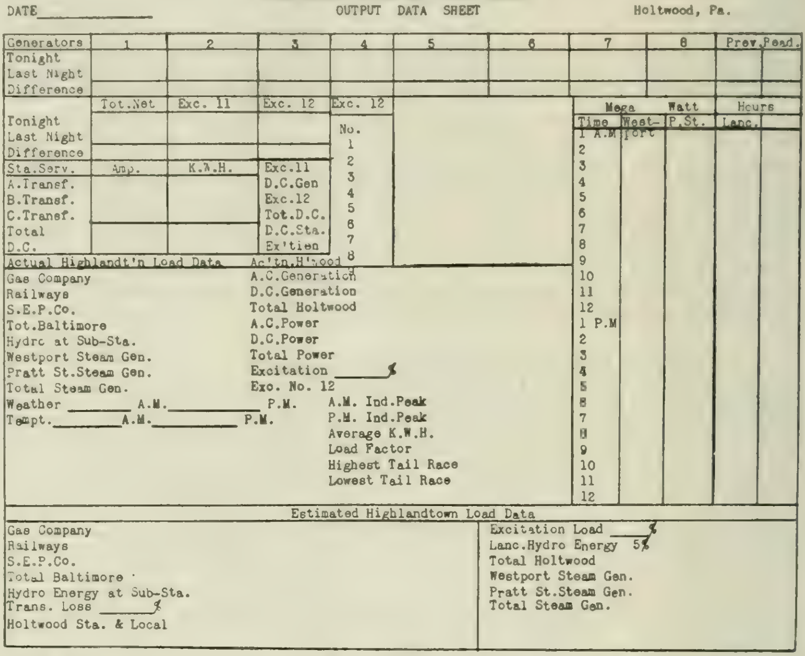
Notice that the river energy, that is, the number of kilowatt hours available from the river flow, also the leakage through the flashboards, and overflow, are recorded. The "K.W. Equivalent" item calls for the number of kilowatt-hours produced per cubic foot of water.



DATE____________ PENNSYLVANIA WATER AND POWER COMPANY Holtwood, Pa.
Watthour Meter Reading Sheet

Gens	1 A.M.		2		3		4		5		6		7		8		Gens
	Read	Diff	Read	Diff	Read	Diff	Read	Diff	Read	Diff	Read	Diff	Read	Diff	Reading	Diff	
1																	1
2																	2
3																	3
4																	4
5																	5
6																	6
7																	7
8																	8

FIG. 4. MIMEOGRAPHED FORMS USED BY THE CREW IN TAKING READINGS



PENNSYLVANIA WATER AND POWER COMPANY
DATE____________ OUTPUT DATA SHEET Holtwood, Pa.

Generators	1	2	3	4	5	6	7	8	Prev. Read.	
Tonight Last Night										
Difference										

	Tot.Net	Exc. 11	Exc. 12	Exc. 12
Tonight Last Night				No. 1 2 3 4 5 6 7 8
Difference				

Sta.Serv.	Amp.	K.W.H.	
A.Transf. B.Transf. C.Transf.			Exc.11 D.C.Gen Exc.12
Total D.C.			Tot.D.C. D.C.Sta. Ex'tien

Mega Watt			Hours	
Time	West-port	P.St.	Lanc.	
1 A.M				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
1 P.M				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Actual Highlandt'n Load Data
Gas Company
Railways
S.E.P.Co.
Tot.Baltimore
Hydro at Sub-Sta.
Westport Steam Gen.
Pratt St.Steam Gen.
Total Steam Gen.
Weather ________ A.M.____________ P.M.
Tempt.________A.M.__________ P.M.

Ac'tn.H'wood
A.C.Generation
D.C.Generation
Total Holtwood
A.C.Power
D.C.Power
Total Power
Excitation ______%
Exc. No. 12
A.M. Ind.Peak
P.M. Ind.Peak
Average K.W.H.
Load Factor
Highest Tail Race
Lowest Tail Race

Estimated Highlandtown Load Data
Gas Company
Railways
S.E.P.Co.
Total Baltimore
Hydro Energy at Sub-Sta.
Trans. Loss ______%
Holtwood Sta. & Local

Excitation Load ______%
Lanc.Hydro Energy 5%
Total Holtwood
Westport Steam Gen.
Pratt St.Steam Gen.
Total Steam Gen.

FIG. 5. MIMEOGRAPHED DATA SHEET USED BY CREW IN TAKING READINGS

The forms, Figs. 4 and 5, were developed by the switchboard operators to facilitate taking readings of the many meters. These forms are mimeographed and used by the men when taking meter readings, which later are transferred to the station log. There is many a plant that might advantageously follow Holtwood's practice in the use of these mimeographed sheets instead of furnishing the men with scrap paper.

Service-Interruption Reports—Fig. 2 shows the service-interruption report form. These are in three colors: Blue for troubles originating at Holtwood station; buff for the transmission lines and substations; white when the cause originates with the customer. Going hand in hand with these reports and attached thereto for transmittal to the chief operator is the service-interruption diagram, Fig. 8, which needs no explanation. The trouble report used in the station is shown in Fig. 7. Notice that the trouble is reported in detail so that the information may be available for transfer to the Machinery Record, Fig. 9.

Dictaphone—Another very interesting feature of the semipermanent operating records at Holtwood is the use of a dictaphone. Dictaphones have been used at the power house and at the principal substation in Baltimore since 1914 as a result of a suggestion made by one of the company's operators. With the aid of a dictaphone, the giving and receiving of messages, operating instructions, etc., are made more systematic. When a phone rings, before removing the receiver the operator simply says the time; then after removing the receiver he gives the name of the station and of himself, repeats then the message to the person who gave it and gives his answer to the question. The person on the other end of the line repeats the answer and the operator confirms the correctness of the other man's understanding by the word "Right." With one operation the conversation is recorded with no guesswork or uncertain recollection of what was said, as the operator can place the reproducer in repeating position and have the time and conversation repeated to himself.

Repeating of all messages over the phone, including orders given verbally to assistants, etc., was Holtwood practice even before the use of the dictaphone, so that no additional time is required for the recording of the conversations on both ends. However, at present a further improvement in this respect is contemplated by the use of a vacuum tube in the receiving apparatus that would energize a loud speaking telephone connected directly to the dictaphone instrument.

The following is from a typical dictaphone record of conversation between the operator at Holtwood and the substation at Highlandtown; record started 4:09 p. m., Mar. 31, finished 4:58 p. m., Apr. 1.

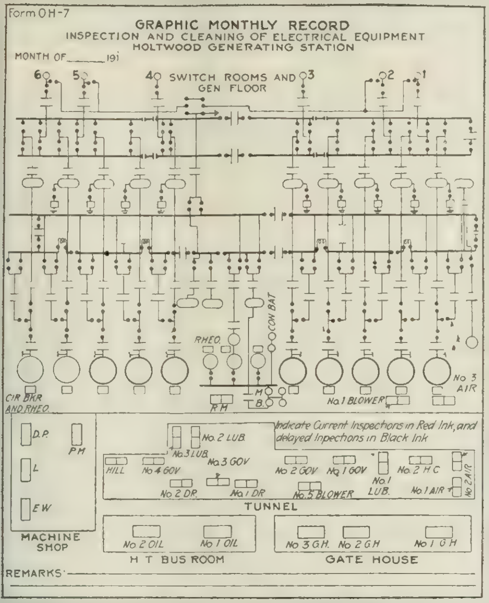
"Mar. 31: 5: 10 p.m. Holtwood; Harvey: Willie, our capacity will probably be reduced to 65,000 over night due to work on the restoring mechanism of No. 5 unit governor. That's right. [The man at Highlandtown has repeated the sentence.] We are not sure you see ——No. I'll let you know if we want stand-by; we ought to be able to go through O. K. without it. I'll call you. All right.

"5:50 p. m. Holtwood; Harvey: Our capacity is now 75,000. No. 5 unit is ready for service. That's right.

"Apr. 1: 12:12 a.m. Holtwood; Shaub: Westport's maximum capacity is 20,500—10,000 available on six boilers, otherwise the same.

To the Patrol Chief: 4:46 p. m. Holtwood; Harvey: Parker at tower 360. Right. No. 1 is clear and ready for service as far as your work is concerned. All right. I'll report you clear on No. 1 circuit, time 4:47. Right."

When a record cylinder is filled, it is removed from


Form OH-7

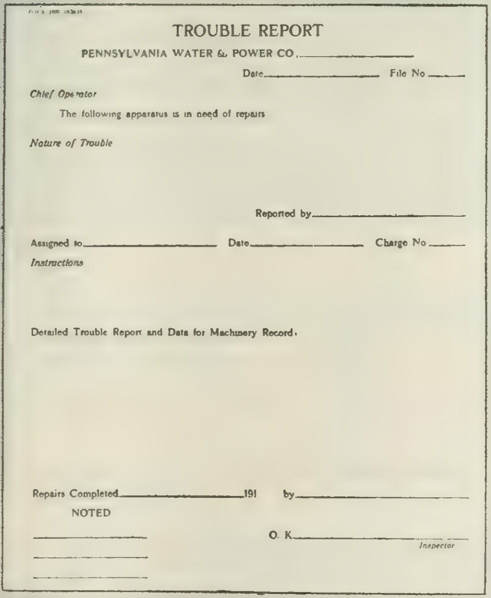
GRAPHIC MONTHLY RECORD
INSPECTION AND CLEANING OF ELECTRICAL EQUIPMENT
HOLTWOOD GENERATING STATION

MONTH OF______191

Indicate Current Inspections in Red Ink, and delayed Inpections in Black Ink

REMARKS:

FIG. 6 (TOP). GRAPHIC MONTHLY RECORD OF INSPECTION AND CLEANING OF ELECTRICAL EQUIPMENT


O.H.S. 1000 10-20-19

TROUBLE REPORT

PENNSYLVANIA WATER & POWER CO.____________

Date____________ File No______

Chief Operator

The following apparatus is in need of repairs

Nature of Trouble

Reported by____________

Assigned to____________ Date____________ Charge No______

Instructions

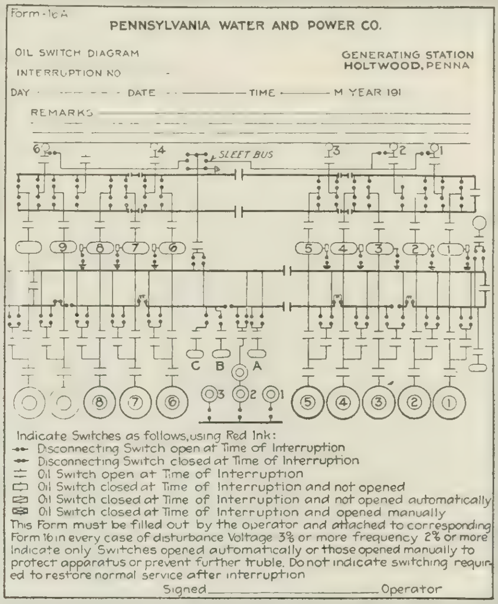
Detailed Trouble Report and Data for Machinery Record.

Repairs Completed____________191 by____________

NOTED

O. K.____________
Inspector

FIG. 7 (BOTTOM). FACSIMILE OF THE TROUBLE REPORT


Form-16A

PENNSYLVANIA WATER AND POWER CO.

OIL SWITCH DIAGRAM

GENERATING STATION
HOLTWOOD, PENNA

INTERRUPTION NO

DAY ------ DATE ------ TIME ------ M YEAR 191

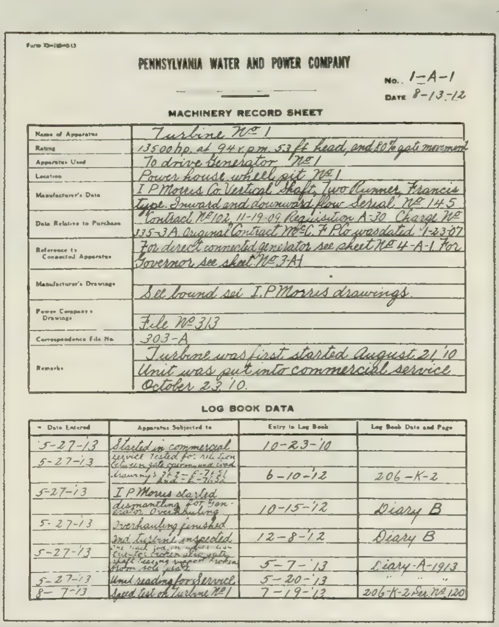
REMARKS

Indicate Switches as follows, using Red Ink:
- Disconnecting Switch open at Time of Interruption
- Disconnecting Switch closed at Time of Interruption
- Oil Switch open at Time of Interruption
- Oil Switch closed at Time of Interruption and not opened
- Oil Switch closed at Time of Interruption and not opened automatically
- Oil Switch closed at Time of Interruption and opened manually

This Form must be filled out by the operator and attached to corresponding Form 16 in every case of disturbance Voltage 3% or more frequency 2% or more Indicate only Switches opened automatically or those opened manually to protect apparatus or prevent further truble. Do not indicate switching required to restore normal service after interruption

Signed____________Operator

FIG. 8 (TOP). GRAPHIC REPORT OF ELECTRICAL INTERRUPTIONS; NOTE THE SYMBOLS USED


Form 70-10-6-13

PENNSYLVANIA WATER AND POWER COMPANY

No. 1-A-1
DATE 8-13-12

MACHINERY RECORD SHEET

Name of Apparatus	Turbine No. 1
Rating	13500 hp. at 94 r.p.m. 53 ft head, and 80% gate movement
Apparatus Used	To drive Generator No. 1
Location	Power house wheel pit No. 1
Manufacturer's Data	I P Morris Co. Vertical Shaft, Two Runner, Francis type. Inward and downward flow Serial No. 145
Data Relative to Purchase	Contract No. 102, 11-19-09 Requisition A-30 Charge No. 135-3A Original Contract No. C. F. P. Co was dated 1-23-07
Reference to Connected Apparatus	For direct connected generator see sheet No. 4-A-1. For Governor see sheet No. 3-A-1
Manufacturer's Drawings	See bound set I. P. Morris drawings.
Power Company's Drawings	File No. 313
Correspondence File No.	303-A
Remarks	Turbine was first started August 21, '10 Unit was put into commercial service October 23, '10.

LOG BOOK DATA

Date Entered	Apparatus Subjected to	Entry in Log Book	Log Book Date and Page
5-27-13	Started in commercial	10-23-'10	
5-27-13	service Tested for relation between gate opening and load drawings [illegible]	6-10-'12	206-K-2
5-27-13	I P Morris started dismantling for Generator Overhauling	10-15-'12	Diary B
5-27-13	Overhauling finished and turbine inspected.	12-8-'12	Diary B
5-27-13	[illegible] broken [illegible] shaft [illegible] broken from sole plate	5-7-'13	Diary-A-1913
5-27-13	Unit ready for Service.	5-20-'13	" " "
8-7-13	Speed test on Turbine No. 1	7-19-'13	206-K-2 Ser. No. 120

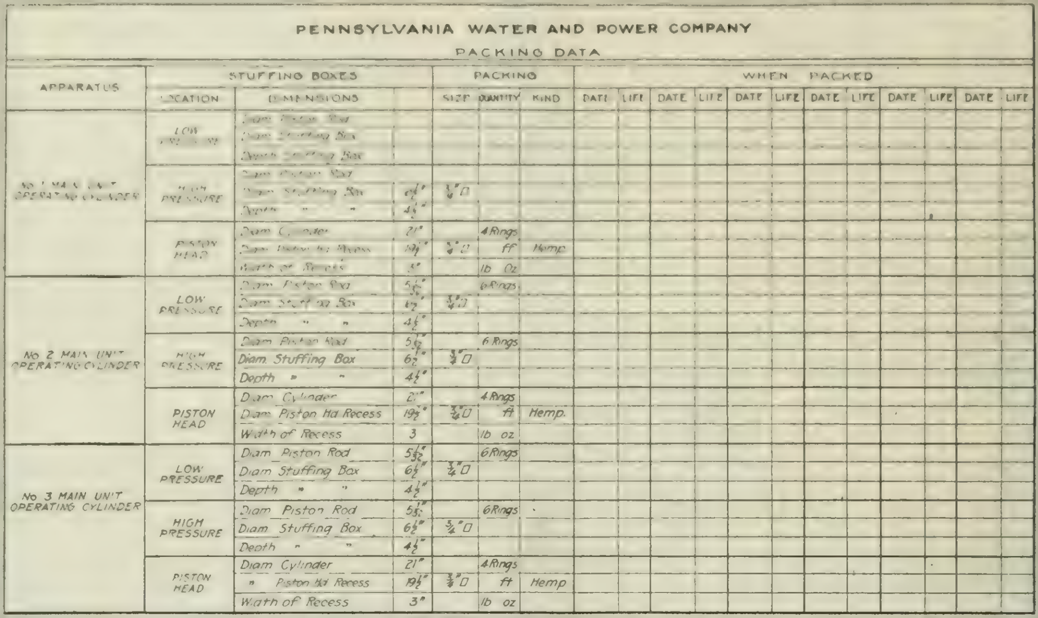
FIG. 9 (BOTTOM). THE MACHINERY RECORD FORM

the mandrel and a new one is put in its place. If there is anything of particular interest recorded on a cylinder, it is marked "Important" and is saved for ten days; if, at the expiration of this time there is no controversy about any of the conversation on the record, it is shaved.

As a rule the records from the power house and substation referring to all abnormal operating events or disturbances are transcribed at the office. They furnish a valuable adjunct in the analysis of all disturbances, showing not only to what extent the operating attendants displayed precision and good judgment in handling any particular trouble, but also paving the way sometimes for further improvements.

Machinery Record Sheet—One of the forms that most impressed the writer is the machinery record sheet, Fig. 9. This particular sheet is typical of the record kept of all machinery worth recording. The value of the form is obvious.

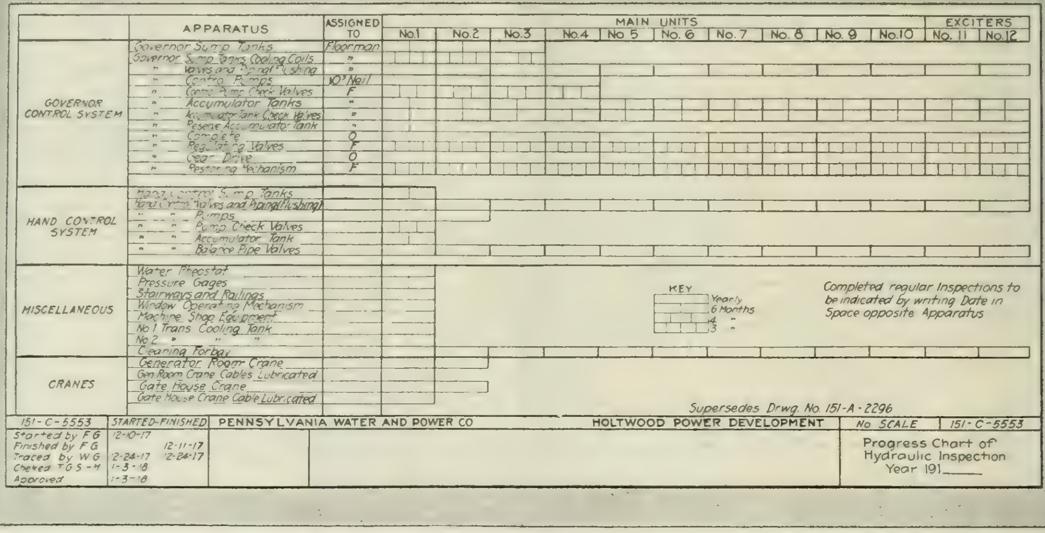
At Holtwood cleaning of equipment, hydraulic and electrical, is assigned to particular men, and such assignments are listed and posted on the station wall in a Rand visible index, thus arguments among the men as to who



PENNSYLVANIA WATER AND POWER COMPANY

PACKING DATA

APPARATUS	STUFFING BOXES			PACKING			WHEN PACKED											
	LOCATION	DIMENSIONS		SIZE	QUANTITY	KIND	DATE	LIFE	DATE	LIFE	DATE	LIFE	DATE	LIFE	DATE	LIFE	DATE	LIFE
No 1 MAIN UNIT OPERATING CYLINDER	LOW PRESSURE	Diam Piston Rod																
		Diam Stuffing Box																
		Depth Stuffing Box																
	HIGH PRESSURE	Diam Piston Rod																
		Diam Stuffing Box	6½"	¾"□														
		Depth " "	4½"															
	PISTON HEAD	Diam Cylinder	21"		4 Rings													
		Diam Piston Hd Recess	19½"	¾"□	ft	Hemp												
		Width of Recess	3"		lb Oz													
No 2 MAIN UNIT OPERATING CYLINDER	LOW PRESSURE	Diam Piston Rod	5½"		6 Rings													
		Diam Stuffing Box	6½"	¾"□														
		Depth " "	4½"															
	HIGH PRESSURE	Diam Piston Rod	5½"		6 Rings													
		Diam. Stuffing Box	6½"	¾"□														
		Depth " "	4½"															
	PISTON HEAD	Diam Cylinder	21"		4 Rings													
		Diam Piston Hd Recess	19½"	¾"□	ft	Hemp.												
		Width of Recess	3		lb oz													
No 3 MAIN UNIT OPERATING CYLINDER	LOW PRESSURE	Diam Piston Rod	5$\frac{1}{32}$"		6 Rings													
		Diam Stuffing Box	6½"	¾"□														
		Depth " "	4½"															
	HIGH PRESSURE	Diam Piston Rod	5$\frac{1}{32}$"		6 Rings													
		Diam Stuffing Box	6½"	¾"□														
		Depth " "	4½"															
	PISTON HEAD	Diam Cylinder	21"		4 Rings													
		" Piston Hd Recess	19½"	¾"□	ft	Hemp												
		Width of Recess	3"		lb oz													



	APPARATUS	ASSIGNED TO	MAIN UNITS										EXCITERS	
			No.1	No.2	No.3	No.4	No 5	No. 6	No. 7	No. 8	No. 9	No.10	No. 11	No. 12
GOVERNOR CONTROL SYSTEM	Governor Sump Tanks	Floorman												
	Governor Sump Tanks Cooling Coils	"												
	" Valves and Piping (Flushing)	"												
	" Control Pumps	10' Neil												
	" Control Pump Check Valves	F												
	" Accumulator Tanks	"												
	" Accumulator Tank Check Valves	"												
	" Reserve Accumulator Tank	"												
	" Complete	O												
	" Regulating Valves	F												
	" Gear Drive	O												
	" Restoring Mechanism	F												
HAND CONTROL SYSTEM	Hand Control Sump Tanks													
	Hand Control Valves and Piping (Flushing)													
	" " Pumps													
	" " Pump Check Valves													
	" " Accumulator Tank													
	" " Balance Pipe Valves													
MISCELLANEOUS	Water Rheostat													
	Pressure Gages													
	Stairways and Railings													
	Window Operating Mechanism													
	Machine Shop Equipment													
	No 1 Trans Cooling Tank													
	No 2 " " "													
	Cleaning Forbay													
CRANES	Generator Room Crane													
	Gen Room Crane Cables Lubricated													
	Gate House Crane													
	Gate House Crane Cable Lubricated													

KEY
Yearly
6 Months
4 "
3 "

Completed regular Inspections to be indicated by writing Date in Space opposite Apparatus

Supersedes Drwg. No. 151-A-2296

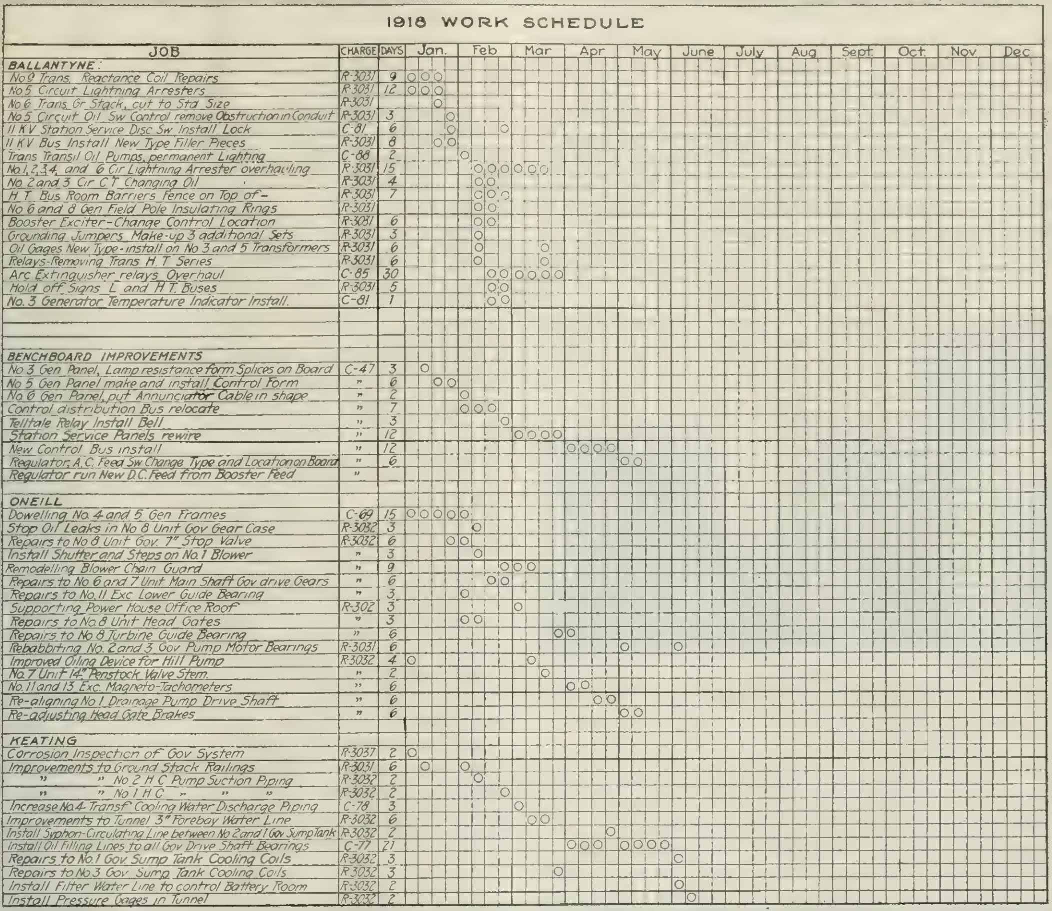
151-C-5553	STARTED-FINISHED		PENNSYLVANIA WATER AND POWER CO	HOLTWOOD POWER DEVELOPMENT	NO SCALE	151-C-5553
Started by F G	12-10-17				Progress Chart of Hydraulic Inspection Year 191_____	
Finished by F G		12-11-17				
Traced by W G	12-24-17	12-24-17				
Cheked T G S - H	1-3-18					
Approved	1-3-18					

FIG. 10 (TOP). PACKING DATA SHEET USED AT HOLTWOOD

A large quantity and wide variety of packing is used. This sheet serves not only as a record of packing sizes and number of rings required for the different stuffing-boxes, but more important, gives the life of each kind of packing used

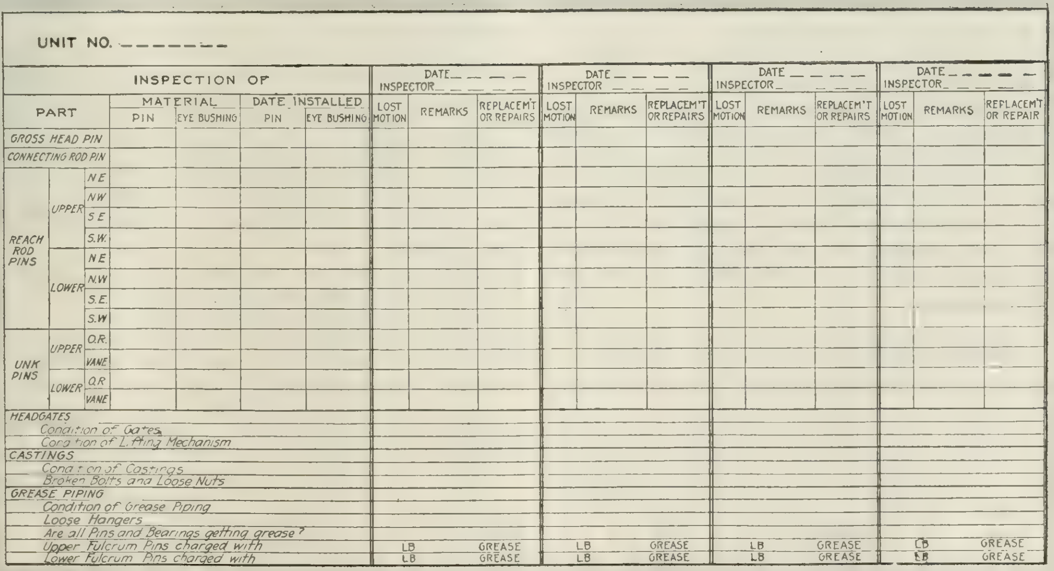
FIG. 11 (BOTTOM). PROGRESS CHART OF HYDRAULIC INSPECTION

The completed regular inspections are indicated by writing the date in the space opposite the name of the apparatus.



1918 WORK SCHEDULE

JOB	CHARGE	DAYS	Jan.	Feb	Mar	Apr	May	June	July	Aug	Sept.	Oct.	Nov	Dec
BALLANTYNE:														
No 9 Trans. Reactance Coil Repairs	R-3031	9	○○○											
No 5 Circuit Lightning Arresters	R-3031	12	○○○											
No 6 Trans Gr Stack, cut to Std Size	R-3031		○											
No 5 Circuit Oil Sw Control remove Obstruction in Conduit	R-3031	3	○											
11 KV Station Service Disc Sw Install Lock	C-81	6	○	○										
11 KV Bus Install New Type Filler Pieces	R-3031	8	○○											
Trans Transil Oil Pumps, permanent Lighting	C-88	2		○										
No 1, 2, 3, 4, and 6 Cir Lightning Arrester overhauling	R-3031	15		○○○	○○○									
No 2 and 3 Cir C T Changing Oil	R-3031	4		○○										
H T Bus Room Barriers Fence on Top of–	R-3031	7		○○○										
No 6 and 8 Gen Field Pole Insulating Rings	R-3031			○○										
Booster Exciter–Change Control Location	R-3031	6		○○										
Grounding Jumpers Make-up 3 additional Sets	R-3031	3		○										
Oil Gages New Type-install on No 3 and 5 Transformers	R-3031	6		○	○									
Relays-Removing Trans H. T Series	R-3031	6		○	○									
Arc Extinguisher relays Overhaul	C-85	30		○○	○○○○									
Hold off Signs L and H T. Buses	R-3031	5		○○										
No. 3 Generator Temperature Indicator Install.	C-81	1		○○										
BENCHBOARD IMPROVEMENTS														
No 3 Gen Panel, Lamp resistance form Splices on Board	C-47	3	○											
No 5 Gen Panel make and install Control Form	"	6	○○											
No 6 Gen Panel, put Annunciator Cable in shape	"	2		○										
Control distribution Bus relocate	"	7		○○○										
Telltale Relay Install Bell	"	3		○										
Station Service Panels rewire	"	12			○○○○									
New Control Bus install	"	12				○○○○								
Regulator, A. C. Feed Sw Change Type and Location on Board	"	6					○○							
Regulator run New D.C. Feed from Booster Feed	"													
ONEILL														
Dowelling No. 4 and 5 Gen Frames	C-69	15	○○○○	○										
Stop Oil Leaks in No 8 Unit Gov Gear Case	R-3032	3		○										
Repairs to No 8 Unit Gov. 7" Stop Valve	R-3032	6	○	○										
Install Shutter and Steps on No. 1 Blower	"	3		○										
Remodelling Blower Chain Guard	"	9		○	○○									
Repairs to No 6 and 7 Unit Main Shaft Gov drive Gears	"	6		○○										
Repairs to No. 11 Exc Lower Guide Bearing	"	3		○										
Supporting Power House Office Roof	R-302	3			○									
Repairs to No. 8 Unit Head Gates	"	3		○○										
Repairs to No 8 Turbine Guide Bearing	"	6			○	○								
Rebabbiting No. 2 and 3 Gov Pump Motor Bearings	R-3031	6					○	○						
Improved Oiling Device for Hill Pump	R-3032	4	○		○									
No. 7 Unit 14" Penstock Valve Stem.	"	2			○									
No. 11 and 13 Exc. Magneto-Tachometers	"	6				○○								
Re-aligning No 1 Drainage Pump Drive Shaft	"	6				○○								
Re-adjusting Head Gate Brakes	"	6					○○							
KEATING														
Corrosion Inspection of Gov System	R-3037	2	○											
Improvements to Ground Stack Railings	R-3031	6	○	○										
" " No 2 H C Pump Suction Piping	R-3032	2		○										
" " No 1 H C " " "	R-3032	2		○										
Increase No. 4 Transf' Cooling Water Discharge Piping	C-78	3			○									
Improvements to Tunnel 3" Forebay Water Line	R-3032	6			○○									
Install Syphon-Circulating Line between No 2 and 1 Gov Sump Tank	R-3032	2				○								
Install Oil Filling Lines to all Gov Drive Shaft Bearings	C-77	21				○○○	○○○○							
Repairs to No. 1 Gov. Sump Tank Cooling Coils	R-3032	3						○						
Repairs to No 3 Gov. Sump Tank Cooling Coils	R 3032	3			○									
Install Filter Water Line to control Battery Room	R-3032	2						○						
Install Pressure Gages in Tunnel	R-3032	2						○						



UNIT NO. ————————

INSPECTION OF							DATE — — — — INSPECTOR — — — —			DATE — — — — INSPECTOR — — — —			DATE — — — — INSPECTOR — — — —			DATE — — — — INSPECTOR — — — —		
PART			MATERIAL		DATE INSTALLED		LOST MOTION	REMARKS	REPLACEM'T OR REPAIRS	LOST MOTION	REMARKS	REPLACEM'T OR REPAIRS	LOST MOTION	REMARKS	REPLACEM'T OR REPAIRS	LOST MOTION	REMARKS	REPLACEM'T OR REPAIR
			PIN	EYE BUSHING	PIN	EYE BUSHING												
GROSS HEAD PIN																		
CONNECTING ROD PIN																		
REACH ROD PINS	UPPER	N E																
		N W																
		S E																
		S.W.																
	LOWER	N E																
		N.W																
		S.E.																
		S.W																
UNK PINS	UPPER	O.R.																
		VANE																
	LOWER	O.R																
		VANE																
HEADGATES																		
Condition of Gates																		
Condition of Lifting Mechanism																		
CASTINGS																		
Condition of Castings																		
Broken Bolts and Loose Nuts																		
GREASE PIPING																		
Condition of Grease Piping																		
Loose Hangers																		
Are all Pins and Bearings getting grease?																		
Upper Fulcrum Pins charged with							LB		GREASE	LB		GREASE	LB		GREASE	LB		GREASE
Lower Fulcrum Pins charged with							LB		GREASE	LB		GREASE	LB		GREASE	LB		GREASE

FIG. 12 (TOP). HYDRAULIC YEARLY WORK SCHEDULE. FIG. 13 (BOTTOM). HYDRAULIC INSPECTION FORM

will do this and do that never happen; instead, equipment is properly cleaned. Definite assignment of caring for apparatus furnishes quite an incentive to individual members of the force to make a creditable showing within the sphere of their responsibility no matter how small these duties may be.

Especial attention is given electrical apparatus. A cleaning progress chart, or list on which every piece of electrical apparatus is designated, together with dates and names of men assigned to clean particular apparatus, is inclosed in a glass-front case on the wall (see the headpiece). As each apparatus is periodically cleaned, the date is entered and the name of the apparatus checked off. Fig. 6 shows the graphic monthly record of inspection and cleaning of electrical equipment. Notice that current inspections are indicated in red ink and delayed inspections in black ink.

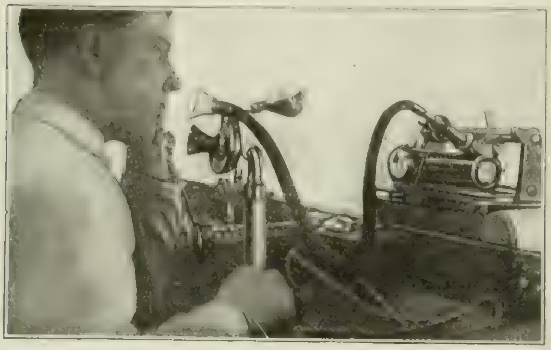


FIG. 14. SWITCHBOARD OPERATOR GIVING INSTRUCTION TO SUBSTATION BY 'PHONE

His conversation is recorded on the dictaphone. Note the watch hanging on the front (left) of the dictaphone.

Progress Chart of Hydraulic Inspection—Fig. 11 shows one of the progress charts of inspection of hydraulic machinery. The key to the various rectangles is given on the chart. Thus some machinery is to be inspected annually, others every six months, some every four and others every three months.

As each called-for inspection is made, the date is written in the corresponding rectangle.

The Yearly Work Schedule—Of all the forms used at Holtwood, the writer believes that the yearly work schedule holds first place in point of value as related to maintenance and operation. This schedule chart is shown in Fig. 12; notice that it applies to the whole station—to electrical and hydraulic equipment.

When the job called for is done, the corresponding circle is inked in in red; if half done, half the circle is inked in.

Delray Station To Be Revamped

Plans have been perfected by the Detroit Edison Co. for the installation of a new 30,000-kw. unit in plant No. 2 at Delray. To receive it, an extension will be made to the turbine room and a new switchhouse will be built. Work on the foundations has started already, and it is thought the unit will be ready for service some time next winter. At the present writing plant No. 1 can carry a maximum load of 40,000 to 44,000 kw. and in plant No. 2 the ultimate capacity is 62,000 kw., made up from four machines, three having a nominal rating of 14,000 kw. each and the fourth, 15,000 kw. By the addition of the new unit and with more economical loading of the older machines, the Delray stations will carry handily 130,000 kilowatts.

It so happens that Delray is long in boilers, or will be when the new unit is installed, owing to its low water rate, so that instead of installing a sufficient number of boilers to carry the new unit, it will be necessary to add only two 1300-hp. Stirling boilers of the same type as the 2365-hp. boilers that have long made this plant a leader in steam generation. This is explained by the fact that the new unit will carry 20,000 kw. on the same quantity of steam required by a 14,000-kw. machine. Then by adding sufficient boiler capacity to carry 10,000 kw., the load considered normal for one of the large boilers or the two new boilers, ample provision has been made for the 30,000-kw. unit.

It is the plan to remove two of the older machines eventually, one 14,000-kw. and one 15,000-kw., to make room for another 30,000-kw. unit, and finally to substitute a third large unit for the two oldest machines remaining.

Delray revamped will be a refinement of Connors Creek practice. The new G. E. unit, rated at 30,000 kw. will generate three-phase 60-cycle 12,200-volt current, the steam conditions being 200 lb. pressure and 200 deg. of superheat, and the speed 1800 r.p.m. The generator leads will be tied solidly to the low-tension terminals of a three-phase compensator-type 12,200- to 24,400-volt transformer. This will feed through single-conductor cables carried underground to the machine switches located in the switchhouse which is being built at the north end of the Delray site. There will be no main switching done in the power house proper.

On the steam end the condenser auxiliaries will be driven by direct-current motors to insure a wide range of speed variation and convenience of operation. To effect a heat balance, the plant will be provided with an auxiliary turbine exhausting into a heater condenser. To conform with the motors, the generator will be a direct-current machine. Sturdiness and simplicity of control are the reasons assigned for the choice of direct-current apparatus.

As the energy required by the auxiliaries is not at all times proportional to the load on the main generator, there will be times when the auxiliary-power demands, if supplied entirely by the auxiliary turbine, would involve an excess of exhaust steam—more than enough to heat the condensate from the main unit. At other periods the conditions may be reversed. To meet this situation, a synchronous motor-generator set will be installed.

When the load on the main unit is light and the auxiliary apparatus requires more energy than the auxiliary turbine will supply, incidentally to heating the feed water, the deficiency will be made up from the main bus through the motor-generator set, and this source will be drawn on should the auxiliary turbine be out of commission. At times of heavy load, when in order to heat the feed water it will be necessary to generate more energy than the auxiliaries require, the surplus will be transformed to the main bus through this same motor-generator by reason of its flexibility. This arrangement should prove an advance over former practice.

There will be a rearrangement of steam piping in the station, and as at Connors Creek, direct-current motors will be used to drive the blower equipment.

Conditions in the Power Industry Abroad

By L. W. ALWYN-SCHMIDT

A digest of reports of United States consuls on the power situation in various parts of the world and the influence of the war on this important industry.

MANY months have passed since the armistice was declared, but little actual progress has been made so far in the resumption of large construction work and public enterprise. Much of the present stagnation no doubt is caused by the very unsatisfactory situation in Europe. Only the neutral countries appear to have continued work on those of their hydro-electric enterprises that were in building when the declaration of the armistice suddenly brought a change in the general situation. Building has remained active in Norway and Sweden.

Available Hydro-Electric Power in Norway, Sweden and Iceland

Commerce Reports has given the European hydro-electric situation a great deal of attention, and a recent issue contains an extensive description of the situation in the two countries. It is said in this report that the total power available in Norway for development is estimated at 15,000,000 hp., while Sweden has a total reserve of 6,000,000 hp. Norway so far has developed 1,300,000 hp., while 950,000 hp. has been developed in Sweden. Norwegian water power has obtained its largest support from the electrochemical industry which has settled in recent years in that country, attracted by the extensive hydro-electric powers that might be obtained. The total developed hydro-electric power in Norway is 0.5 hp. per person, but it is only 0.17 hp. in Sweden.

Both countries have numerous developments owned as a rule by municipalities or operated under local concessions. The war has shown that many of these plants are operated on a wasteful basis, and especially that a great number of them are working on too heavy a load, making operation unnecessarily expensive, while others have a much larger output than is actually required. To correct this situation it is now contemplated to unite all the hydro-electric enterprises in a single district for the purpose of coöperative operation. The first experiment of this kind was made in central Sweden, where 33 stations have been combined. The new company will exert a sort of controlling influence in its district by directing the power production and distribution in the most economic channels. The Swedish government also is very active in promoting power development. The water-power commission, which already had $2,200,000 at its disposal this year for the purchase and extension of existing water-power developments, has asked for authorization of an additional $268,000, and $670,000 will be required during 1920.

More specific information is now obtainable on the new development contemplated in Iceland. The work for this enterprise is in the hands of a Norwegian company financed by Norwegian and Icelandic interests. The whole system will consist of a series of plants, the largest of which will be erected on the Thorsaflod, the principal river of the island. Other stations will be located at points on the tributary rivers of the main system. The local conditions for erecting the plant appear to be excellent, and it is estimated that the Iceland consumers will get their electricity as cheaply as it is sold to consumers in Norway. The total development, which may consist of six individual but interconnected stations, will produce approximately 1,114,000 horsepower.

The Water Powers of Finland

The development of the water powers of Finland has been held back in recent years by the inability of the Russian government to provide the necessary means. Finland is very similar in its topographic appearance to the other Scandinavian countries. There are high mountains approaching the sea and many rivers with powerful falls. The new Finnish republic is now making an attempt to develop part of the existing resources either by private or by government enterprise, and plans have been drawn for a hydraulic plant yielding 118,000 hp., to be located just north of Viborg. The power will be gained from a fall of the Imatra River of 68.9 ft. The cost of the whole development is estimated to be from $18,000,000 to $24,000,000. Pre-war estimates amounted to $6,000,000 only. To secure an even flow of water it is intended to make use of the Saimaa Lake, which would permit the additional use of the Vuoksen Rapids. This would add approximately 500,000 hp. to the total possible development. The present plans of the Finnish government contemplate a linking up of all the existing minor enterprises along the Vuoksen.

The present hydro-electric activity in northern Europe, including the large project in Iceland, deserves the closest attention of the American power industry. Governmental enterprise will aid in the construction of many of the new developments, but there is plenty of room for private construction. This applies especially to Finland, in which industrial progress was held back in pre-war times by the lack of coal and capital. The new republic will now have to aid in the building up of a new national industry so as to make the country reasonably independent of foreign supplies. The first step must be to supply cheap and reliable power. Full support, therefore, will be given to foreign enterprise likely to aid in the exploitation of the power resources of the nation. American capital no doubt will be welcome and its employment will be followed by orders for American power machinery and general equipment. American capital also may come handy in the development of the power-consuming industries, such as the electrochemical industry, which appears to find a very fertile field in the Scandinavian countries. So far English capital has been most prevalent in financing these enterprises with the result that much power equipment has been ordered from English firms.

Hydro-Electric Development in Great Britain and France

Accessibility to coal has so far retarded hydro-electric development in England. With coal directly at the doors of the power houses, so to speak, there was little reason to spend large amounts of money in the erection of costly water-power stations. The increasing cost of coal and frequent labor troubles at the mines have now directed more attention to the hydro-electric possibilities of England and Scotland. There are very few water-power sites available in the south of England. More can be found in the north, and their number grows with the crossing of the Scottish border. A survey of the most promising power sites in Scotland seems to show that between 375,000 and 650,000 hp. may be made available, and authorization is now being sought by promoters to permit the development of certain sites.

The government so far has not been very ready to grant exploitation rights of water-power sites, as the whole question of supplying England with electrical power is still under discussion. The large coal interests naturally view with disfavor any enterprise that might lead to a reduction in the coal consumption, and it is likely that at first an attempt will be made to carry out the intended linking up of the great power stations in the Midlands, which has been referred to several times in the course of these reports.

The inquiry into the hydro-electric resources of France, which has been undertaken as a result of the war, is proceeding and it is now estimated that France will have at her disposal approximately 5,000,000 hp. that may be available all the year round and another 5,000,000 hp. available during only six months of the year. Of this, 750,000 hp. was developed before the war. The French government has rapidly pushed forward all the work under way during the war and it has been possible to add 415,000 hp. during the last four years. Several other projects were begun during the last year, but have not been completed. These comprise the development of 125,000 hp. during 1919 and 225,000 hp. during 1920 and 1921. When these are completed, France will have at her disposal 1,600,000 hp. derived entirely from water power.

South American Markets for Power Material

The war has broken the dominating influence of the German electrical industry in South American markets. It is estimated that the total consumption of electrical goods in South America amounted to $22,000,000 during 1913. Of this, $10,000,000 worth was supplied by Germany, $5,400,000 by England and $4,500,000 by the United States. Since the outbreak of the war Germany has practically vanished from the market and the United States imports have grown to nearly $10,000,000. The largest of the South American markets for power material is Argentina.

Argentina, unfortunately, is somewhat handicapped in developing electrical power owing to its lack of water-power sites. The only large waterfall is the Iguassu, which is situated on the Argentina-Brazil boundary, but it is too far removed from the present centers of electrical consumption to be of real use. There are, however, hydro-electric enterprises in Tucuman and Cordoba. It is estimated that Argentina employs today about 130,000 hp. of electrical energy in industrial enterprises and the electric motor power increases at the rate of 6000 hp. annually. The largest of the central stations in Buenos Aires is under German control, and German capital also is invested to the extent of $24,000,000 in many other electrical enterprises in Argentina. A second power station in Buenos Aires is financed by Swiss-Italian interests. Most of the equipment imported by these two companies is European. The electric railroads are using principally English or German motors.

The second consumer of electrical-power material of importance in South America is Brazil. The two largest central stations, those in Rio de Janeiro and Sao Paulo, are owned by the Brazilian Traction, Light and Power Co., which is a Canadian company. The Sao Paulo central-station plant supplies power to electric motors totaling 50,000 hp. and that in Rio Janeiro to 100,000 hp. There are several good prospects for the development of water power in the state of Minas Geraes. The country is rich in large and small streams falling rapidly in the direction of the coast. At the present time little use has been made of the existing opportunities, as the principal power sources are too far removed from the distribution centers to make worth while their exploitation. The largest available sites are those of the Sete Quedas, providing for 20.000,000 hp., the Iguassu with 3,000,000 hp. and the Paulo Affonso with 1,500,000 hp. Many of the smaller rivers have been harnessed successfully, providing power for neighboring cities. industrial enterprises and mines.

In Uruguay most of the existing central stations are owned by the government, which has a central management office in Montevideo. There is small chance for hydro-electric development and lack of coal makes necessary the use of Diesel engines for power generation.

Chile, the third market in importance for electric-power equipment in South America, has lately shown remarkable activity in the development of her hydro-electric resources. In the section from Coquimbo to Valdivia there is an abundance of water power, and the government has created a commission to study the possibility of constructing a longitudinal artery for the transmission of power through this stretch. The two large central stations in Santiago and Valparaiso are under German control.

There are several small power developments under way in South and Central America. In Nicaragua the cities of Granada and Leon are discussing the question of building electric-power stations, and an American consulting engineer has made an investigation of the available water power near Granada. In Cuba steps are being taken to rebuild the power station in Nueva Gerona on the Isle of Pines, which was destroyed during a hurricane. The Legislative Council of Guadeloupe has just granted a franchise for the control of two waterfalls that will furnish power for the operation of electric railways in the colony.

Power Development in British India

The government of India intends to have a survey made of the hydro-electric resources of British India. The British government has decided that the development of water-power sites in India cannot longer be left to private enterprise and that the government will have to undertake this work. "Owing to the great value of the natural-power resources of a country," the India Office says in a letter to the provincial governments, "it is important that each site should be developed to its full potentialities and to prevent small concerns developing the best sites for the purpose of schemes requiring limited quantities of power only, when they might have been developed into larger projects of more general public utility." The government will now make an examination of those sites already known and others will be charted so that they may be made available when required.

Flat Spots on Commutators *and* Collector Rings

By

*Warren C. Kalb**

ONE of the most annoying troubles encountered in the operation of electrical machinery is the flat spot which frequently develops on both collector rings and commutators. The spots may result from a variety of conditions, and the exact cause in a given case is often difficult to ascertain. It is the purpose of this article to discuss some of the more frequent causes of this trouble and to point out how they may be overcome.

One of the most common causes for flat spots on collector rings is vibration which makes the brush break contact with the ring, producing a burned spot on the surface. This condition is especially troublesome if the vibration is of periodic character, breaking the contact of the brush repeatedly at the same spot on the ring. It may result from unequal expansion of the ring destroying its true cylindrical form as the machine warms up. This fault is most likely to occur with spoked rings of light cross-section. In some cases the trouble may be corrected by grinding the ring after it has been heated up to operating temperature. It is well, where possible, to perform this grinding operation at the full running speed of the machine, as at this speed there may be a distortion that does not exist at lower speeds. If the trouble continues after this has been done, it may be necessary to change the design of the ring, giving it a form that will not become distorted under the conditions of speed and temperature encountered in service.

Other sources of troublesome vibration are brushes too loose in the holders, insecure mounting of brush-holders, loose bearings, pound of reciprocating engines and a mechanically unbalanced rotating element. The remedy in all these cases is to correct the mechanical fault. It is wrong, as is sometimes done, to try to overcome a mechanical fault by the use of an abrasive brush.

Chattering of the brushes is a form of vibration that is frequently a source of spotting. It may be due to a loose brush-holder or too much clearance between the brush and the holder. Clearance between brush and holder, in the direction of rotation, should not exceed 0.01 in. at operating temperature, and even less clearance is desirable. Chattering may also be due to the use of a brush with too high a coefficient of friction for the peripheral speed of the ring on which it is operated. In this case it is best to select a brush with a lower coefficient of friction.

Where the rotative speed of the ring is very high, as is often the case with turbo-alternators, it is sometimes found advantageous to use a brush of low specific gravity. The lower inertia of such a brush, as compared with that of a brush of high density, enables it to be held in more intimate contact with the ring.

The construction of the brush-holder and the angle at which it is set are points having an important bearing on the tendency of the brush to chatter. Clamp-type brush-holders, Fig. 1, should never be used on very high-speed rings or commutators, as the inertia of the holder added to that of the brush is liable to cause considerable jumping even where the inequality of the contact surface is very slight. Even the weight of a rigid pressure arm, as illustrated in Fig. 2, may be sufficient to allow some chattering of the brush, which can be eliminated by the use of a light flexible blade on the under side of the pressure finger, as shown in Fig. 3.

Brushes operating in the leading or stubbing position should be inclined at a sufficient angle from the radial to insure the brush riding steadily against the leading side of the brush-holder. If the brush is set too near radial, the friction will pull it away from the leading side of the holder, tip it up on the toe and chattering will follow. An inclination of 30 deg. or more should be used when operating in this direction. Leading operation is illustrated in Fig. 2.

In trailing operation the inclination of the brush should not be so great as in leading. With too sharp an angle there is a wedging action of the brush between the ring or commutator and the trailing side of the holder, resulting in excessive friction and a sluggish action of the brush in the holder. The best angle for trailing operation will usually lie around 12 deg. to 15 deg. Fig. 3 illustrates this position.

Flat spots on rings sometimes result from hard or soft spots in the material composing the ring. This is a somewhat common fault in cast-iron rings, and spongy spots are of rather frequent occurrence in bronze rings, especially where the composition is very high in copper. Best operation on rings of this nature is generally obtained by using a brush with some polishing or even a slight abrasive action. This may result in noticeable ring wear, but if flat spots are avoided by this means, the ultimate ring life will probably be greater than would be the case where frequent turning is necessary to remove flat spots.

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*Engineer, Corliss Carbon Co., Bradford, Penn.

Current left on when the machine is standing is a less common cause of flat spots than those previously mentioned, but one that may sometimes be found even with field rings where the current might not be thought excessive. The temperature attained at a brush contact on a stationary ring is higher than might be realized at first thought.

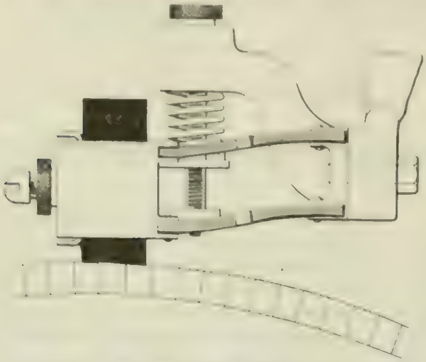


FIG. 1. CLAMP-TYPE BRUSH-HOLDER

Surges of current due to short-circuits, sudden peak loads, hunting between machines operated in parallel or static disturbances are liable to produce small burned spots on collector rings which, if not cleaned off, may develop into spots of considerable size. The original cause in such cases may be beyond the control of the operator so that all he can do is to see that the ring is put in proper condition after the injury to its surface has taken place.

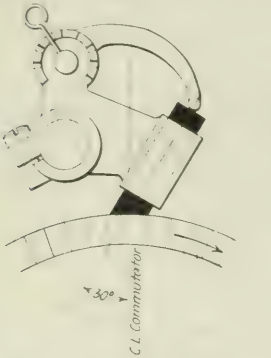


FIG. 2. BRUSH OPERATING IN LEADING POSITION

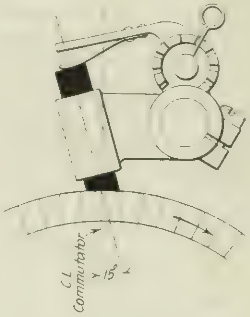


FIG. 3. BRUSH OPERATING IN TRAILING POSITION

Perhaps the most common cause for the development of flat spots on commutators is high mica. This condition results in small arcs being drawn between the brush and the edge of the commutator segments. The burning of the segments is cumulative in its action and will usually be of greater severity at certain points on the commutator than at others, due to a lack of perfect symmetry in some electrical or mechanical characteristic of the machine. If the condition is not corrected, flat spots will sooner or later develop at these points. Some of the causes of high mica are: Difference in hardness of the mica or of the commutator segments; lack of abrasiveness in brushes operated on hard, flush mica; sparking, whatever the cause may be; poorly seasoned mica. The last-named fault arises through the mica expanding and projecting beyond the copper. This may disappear after the commutator has been turned a few times due to the seasoning that takes place at operating temperatures. When this fault is found, the commutator should always be tightened before turning, as the baking out of the mica may leave the segments loose.

Sparking may result from such a variety of causes that a discussion of this point will not be undertaken in this article. Where possible, the cause of the sparking should be located and removed. Where the two remedies mentioned are not applicable or high mica recurs after they have been tried, the best procedure is to undercut the mica below the surface of the copper. The other alternative is to select a brush of sufficient abrasiveness to cut the mica down as rapidly as the copper is burned.

As is the case with collector rings, vibration is a frequent cause of flat spots on commutators. The sources of vibration named for collector rings apply as well to commutators. A cause of flat spots peculiar to commutators is high or low bars. Where this fault is found, tighten the commutator and grind or turn it to a true cylindrical surface.

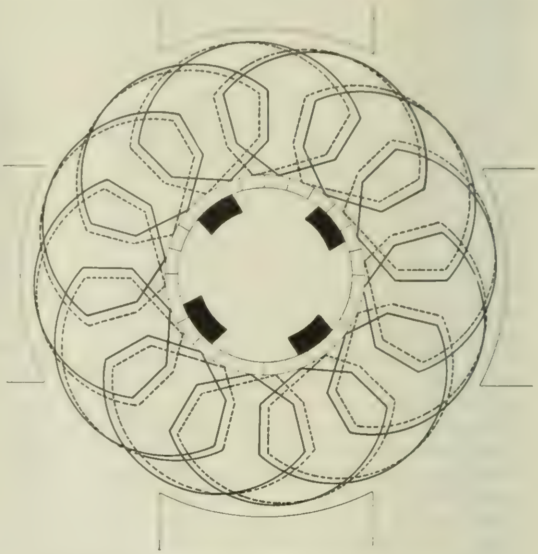


FIG. 4. DUPLEX ARMATURE WINDING

Surges of current are another source of flat spots common to commutators and collector rings. In addition to the causes named when considering collector rings, heavy surges may be thrown on the commutator of a rotary converter by putting it on the line when it is not in exact phase.

Flat spots are produced by unbalanced circuits within the armature winding, such as may occur when there is an open-circuit, a high resistance connection or a coil wholly or partly short-circuited. The remedy, of course, is the correction of the electrical fault.

Flat spots evenly spaced around a commutator are always traceable to a source having a periodic characteristic. This fact is often of assistance in locating and removing the cause. Periodic vibrations, such as may result from the pound of a reciprocating engine or the changes in angular velocity found on a generator driven by a gas engine lacking in flywheel capacity, will be accompanied by equidistant spotting of the commutator.

Unbalanced circuits in the armature winding sometimes cause several flat spots around the commutator, due to disturbances created in parts of the winding other than that containing the electrical fault. In such cases the spots will usually be spaced at twice the distance between brush studs. Hunting of a periodic character is a source of evenly spaced flat spots, the spacing depending on the relation between the frequency of the hunting period and the speed of the machine.

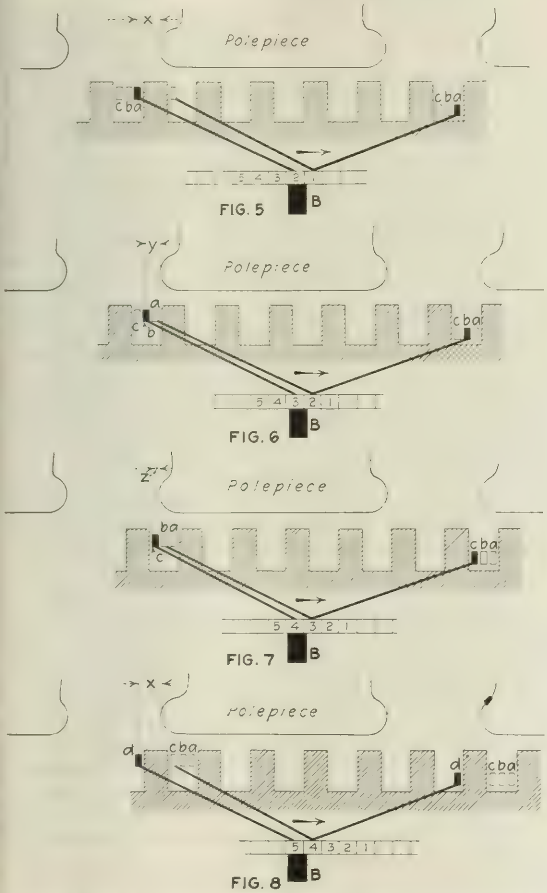


FIG. 5

FIG. 6

FIG. 7

FIG. 8

FIGS. 5 TO 8. EFFECTS DURING COMMUTATION IN A WINDING HAVING THREE COILS IN A SLOT

Spotting of every second or third bar is a condition which may result where the armature has a duplex or triplex winding the parts of which are not evenly balanced. A duplex winding is shown in Fig. 4, and it can readily be seen that a condition in one portion of the winding tending to burn the commutator segments would affect only every other segment, the intermediate segments being connected to the other portion of the winding, and unaffected by the disturbing condition. This condition may arise even when the windings in themselves are perfect, owing to the fact that commutation does not take place simultaneously in the two sections of the winding. An examination of Fig. 4, in which the coils of both windings are shown in the same slot, will show that commutation in one section takes place later than in the other, the angular difference in time being the angular displacement of one segment. If the neutral or commutating field is narrow, this difference in time of commutation may be sufficient to prevent setting the brushes so that perfect commutation is secured in both windings, and burning of every other segment will result.

A similar condition arises in the case of a simplex winding where there is an insufficient number of slots in the armature, resulting in placing several coils in one slot. The condition arises, in this case, from the fact that several coils are grouped close together in one slot while the segments to which these coils are connected are evenly distributed around the commutator. Figs. 5, 6, 7 and 8 illustrate this condition. In Fig. 5 commutation in coil *a* is just being completed by the segment 1 passing from under the brush *B*. The coil at this time is at the distance *x* from the following pole tip.

In Fig. 6 the commutator has moved the width of one segment and coil *b* is just completing commutation. It will be noted that its distance *y* from the pole tip is less than *x*, Fig. 5. Similarly, in Fig. 7 commutation is seen to be completed in coil *c* when it is a still smaller distance *z* from the pole tip. Coil *d* in the following slot, Fig. 8, completes commutation at a distance *x* from the pole tip, the same as coil *a*. It is evident that when the brushes are so set as to give perfect commutation in coil *a*, there is likely to be some sparking from coil *b* and commutation may be so poor in coil *c* as to cause serious burning of the segments to which it is connected. This condition would result in the spotting of every third bar of the commutator.

To avoid the foregoing difficulty there should be not less than 3½ slots in the space between poles. This allows a wide enough commutating zone for all the coils to commutate properly. Inasmuch as the space between poles is usually about 30 per cent. of the pole pitch, there should be not less than 12 armature slots per pole. In large machines less than 14 are seldom used.

Fallacy of Haphazard Records

By C. C. Raitt

While there is no doubt that the records of the operation of central-station equipment can play a large part in increasing the efficiency of the plant, it is also true that records that are not accurately kept are not only useless, but may be the cause of much wasted time and effort. There is no meter that will run on indefinitely and give accurate results without periodic checking, and this is especially true of the flow meters available at the present time. Flow meters have not yet reached a stage where they can be considered sturdy.

The conditions under which they are expected to operate are anything but desirable for a delicate mechanism. There is invariably a quantity of fine coal dust in the air around a boiler room, and there is sure to be considerable vibration in the building. Therefore, if there is to be an accurate record of steam flow, someone must make frequent inspection of the meters and keep them clean and carefully adjusted.

In many cases where flow meters have been installed and the readings used for various calculations month after month, it has been found later that the meter had gotten out of adjustment and the readings were all wrong. No doubt there are instances where it is impossible to get a check on the flow meters and know whether they are working properly. When this is true, it is doubtful if the meters are a wise investment. However, in most cases, the capacity of the turbines or the boilers metered, together with the readings of other meters working in conjunction, should give a sufficient check on the readings of a meter.

At this point it would be well to explain just what is meant by checking a meter by the capacity of the equipment metered. It certainly does not mean that an estimate of steam flow, based on the capacity of the equipment metered, is to be given precedence over the readings of the meter and used whenever meter readings do not look satisfactory. But it does mean that whenever the meter readings do not agree with the estimate, it is time to hunt the trouble.

It should be hunted first in the meter, and if the meter is proved to be correct the reading should hold and the trouble should be hunted in the metered equipment. There is always a tendency to assume that the operation is normal and the meter wrong because it is so easy to estimate what the reading should have been and let it go at that. But whenever this is done, the purpose for which the meters were installed is defeated. A meter reading should be considered right until it is proved wrong.

In determining the pounds of coal burned in the plant, a number of difficulties arise. Where the coal burned is not of uniform size, it is difficult to obtain the weight by measuring volume. Even though it may be bought in uniform size or crushed in the station yard, there is still the danger of ice causing lumps to form which interfere with the measurements. It is best to weigh all the coal burned if possible.

Here, again, there is an opportunity for errors unless the weights are automatically recorded. It is only human to make mistakes and to be negligent where there is no check on a man's work. Therefore, to trust an employee to put down the weights without any way of knowing whether he is doing it properly or not is to invite trouble.

If it is true that the automatic mechanisms we use need care and attention, it is even more true that the human element in our records must be watched. And so it is not enough to provide means for weighing all coal burned, but some method—automatic if possible—should be used to make sure that all coal is accurately weighed.

Oil and Fuel Troubles in a Diesel Engine

By D. L. Fagnan

Poor lubrication of pistons, accompanied by excessive wear on piston rings and liners, developed in a Diesel engine. Examination showed that the crank-case oil was fairly good, but that the pistons were lubricated by an old-style force-feed lubricator. It was therefore advised that a new-style lubricator be purchased and installed, as this is timed to inject the oil in synchronism with the piston movement. That is, the oil is injected at the dead-center position of the piston at the beginning of the power stroke, so that it acts to seal the piston rings and lubricate the liner at a time when the piston is doing the most work and lubrication is most needed.

Naturally, oil delivered by the old-style lubricator to the four openings in the cylinder liners sometimes is injected at the proper time; but as other pistons may have passed the openings, any oil injected at such time does no work and is of no benefit. Instead, it helps to form carbon in the cylinder. To obtain greater benefit, the piston should be in position to receive the lubricant on its outer circumference, directly between the third and fourth rings, while it is practically at a standstill. This is the dead-center position, and so the timed lubricator gives the most efficient service on Diesel engines. A set of gears attached to the layshaft is used for timing. From 15 to 20 drops of oil per piston per minute is average practice on engines up to 225 hp. at 164 r.p.m. Above this speed proportionately more oil should be used, 30 drops per minute for larger engines being about the maximum.

By means of a bent wire it was found that the suction check on the main fuel tank was badly adjusted, and this adjustment was remedied to prevent silt, sand and such rubbish from being picked up and carried to the auxiliary fuel tank. Considerable grit had been sucked up and no doubt had caused the fuel nozzles to cut badly. They had to be reground practically every two weeks, whereas once a month should be sufficient.

All piston rings on the engine were removed, all valves, fuel nozzles and seats ground in, and new fuel-cam noses put on to replace those that were worn. The gears were checked for correct timing, and the cylinder walls were smoothed up by scraping and polishing with emery cloth. The oil in the crank case was renewed, the bearings keyed up all around, the piston pins polished, all jackets and heads washed out with a hose and the water passages examined for scale. After assembling, the engine was started, and the indicator was applied to determine the compression in each cylinder. This was found to be excellent, and no further trouble from excessive wear occurred, while the fuel consumption was notably decreased. Part of the success in providing good lubrication on this engine was due to the change of oil.

Areas of Segments of Boiler Heads

Extreme simplicity and compactness characterize the chart on the opposite page, which is intended to be used for finding the area of a boiler-head segment to be stayed, according to the latest revision of the A. S. M. E. Code. The chart was compiled by C. H. Baker, mechanical engineer, Public Service Electric Co., N. J.

The method of applying the chart may be explained most easily by an example. Suppose that a boiler 90 in. in diameter has a head $\frac{11}{16}$ in. thick and is to carry a pressure of 200 lb. gage, and let it be required to find the area of segment to be stayed, assuming that the height H of the segment is 23.9 in.

Starting from the point indicating 200 lb., on the horizontal line at the middle of the chart, proceed vertically to the curve and then horizontally to the right to the diagonal representing a head thickness of $\frac{11}{16}$ in. From this point drop vertically to the middle horizontal line, which will be cut at a point corresponding to a value of 3.9, indicating that d is 3.9 inches.

From the value 3.9 continue vertically downward to the inclined line denoting a boiler diameter of 90 in. and from that point turn horizontally to the left. As H is 23.9 in. and the value of d was found to be 3.9 in., $H - d = 23.9 - 3.9 = 20$ in. Consequently, proceed horizontally to the curve marked 20 and then vertically to the lower edge of the chart, where a value of 855 will be indiated. Then the area of the segment is 855 square inches.

EDITORIALS

The Engineer as a Social Economist

AT A RECENT gathering of engineers Professor L. P. Breckenridge, who had just returned from his annual tour with the senior class in mechanical engineering of the Sheffield Scientific School at Yale, gave striking expression to a thought which has been gaining form in many minds.

He had stood, he said, at East Pittsburgh and looked down the throat of a great hydraulic turbine designed to develop forty-five thousand horsepower. His first job after leaving college was testing waterwheels with Clemens Herschel at the Holyoke flume. They had less than thirty thousand horsepower, but that "rush of many waters" used to seem to him to be enough to run the universe. Yet here was a single turbine that would drink it all up and call for more. And he marveled at the skill of the engineer who had devised that mechanism that in a few feet of correctly fashioned guides and blading could take the energy out of this flowing mass and, without impact or friction or eddy or confusion, deposit it, quiet and harmless, in the tailrace, its energy converted to the beneficent purposes of industry.

And then they were taken to the stoker department and shown how the black, smudgy, smoky coal was converted into a mass of glowing white incandescence and, after flowing through a few properly proportioned passes of the boiler, escaped as a comparatively cool and colorless gas into the atmosphere, having left some three-quarters of its energy in the steam; and he admired the skill that fashioned the apparatus and controlled so completely the process of converting this great quantity of heat energy at such temperatures without even discomfort to the operators.

And then there were the boilers, each joint and element designed and constructed by the skill of the engineer to withstand with a large reserve of security the enormous pressure upon them; and the turbine where, within a space that could be spanned by the extended arms, that steam was made to give up its energy to the revolving shaft to be converted into electricity for the service of mankind.

And then, as he rode back with his class in the train, he read in his daily paper the stories of strikes and revolutions and other manifestations of social unrest. Empires and thrones and dynasties had been overthrown; millions of people, unused to the free air of liberty, untaught in the problems of industrial administration, had been torn loose from any allegiance to constituted authority; thousands of laborers filled with a new sense of their indispensableness were clamoring for the democratization of industry as well as of the forms of government, for a voice in the determination of the conditions under which they work and live. And he wondered where the skill and tact and expert knowledge was coming from that would devise the method and the mechanism that would direct this mighty force, the man power of the world, to its beneficent purpose, the support and development of the race, smoothly, efficiently, without clash or friction or calamity.

If the water gets away, we have a Johnstown flood; if the fire gets beyond control, we have a conflagration; if the boiler is not properly designed, constructed and operated, we have an explosion; if there is friction or lack of balance in the turbine, it may wreck itself in a few revolutions.

What may be the consequences of a failure properly to understand and direct these great human forces now wasting themselves in friction and eddy and conflict and misdirection? Who better than the engineer with his analytical habit of thought and his methods of applying the forces and materials of nature in the most direct and efficient manner to the benefit of man, can outline and put into execution a plan which will unite administration and manipulation in a system of national production that can be carried at the full rate and at maximum efficiency and in which the standing and emolument of each shall be in proportion to the service rendered?

Size of Transformer for Induction Motor

THE question of the selection of transformers for induction motors is one that has frequently been given too little consideration by those who have applications of this sort to make. The rules and formula given in the article by J. B. Gibbs, on Page 756 of this issue, are extremely simple and practical and will be of great assistance to those making applications of this sort. The information given on emergency connection is of particular value in that by becoming familiar with these schemes it may be possible for an operator to save a long and serious shutdown. In using emergency connections of this kind, care should be taken to see that the reduced capacity of the transformers is given due consideration and, if necessary, the load can be reduced until proper repairs can be made.

As stated by Mr. Gibbs, according to standardization rules of the American Institute of Electrical Engineers and of the National Electric Light Association, transformers are designed to have a temperature rise of fifty-five degrees Centigrade above the surrounding air. Some motors are rated on a fifty-degree Centigrade rise for continuous operation, but there are a large number of motors sold on a basis of a forty-degree rise with the stipulation that they shall be capable of operating under an overload of twenty-five per cent. for two hours after a continuous run with a temperature rise not exceeding fifty-five degrees Centigrade. This would obviously considerably overload a transformer based on fifty-five degrees rise for full-load condition of the motor. The transformer should be either based on forty degrees Centigrade rise or the capacity increased twenty-five per cent. when rated on fifty-five degrees rise.

Where a transformer is used to supply two or more motors, the diversity factor of the various motors must be taken into account, since it is not necessary to supply a transformer having a capacity equal to the combined capacity of all of the motors. This diversity factor depends not only upon the number of motors involved, but also the class of work to which they are applied. For the ordinary machine-shop drive, this diversity will be approximately fifty per cent., which means that the capacity of the transformer feeding a group of motors in the machine shop may be about fifty per cent. of the combined capacity of the motors. For crane operation the diversity factor is very much less. The capacity of crane motors is based on an intermittent rating which is about fifty per cent. greater than their continuous rating. The motors on a crane are seldom all in operation at the same time, and in a group of cranes there are always several idle. The result is that the capacity of the transformers for a group of cranes can be about ten per cent. of the combined capacity of the various motors, based on their intermittent rating. The diversity factor of each group of motors should be given a very careful study before determining the actual size of the transformer required. As pointed out by Mr. Gibbs, if a transformer is too small, it will burn out, and if too large, there will be unnecessary energy loss in the system and an unnecessary investment in transformers.

The N. E. L. A. and Some Power Problems

AFTER a lapse of over two years, during which time its meetings were devoted almost exclusively to problems connecting the industry with the prosecution of the war, the National Electric Light Association Convention this week at Atlantic City will afford central-station men an opportunity to get together for the discussion of their normal problems, both technical and commercial. Many familiar faces will again be seen, and the important committee reports will once more be in evidence.

This year finds the industry confronted with many new conditions and problems. Normal development in certain lines was retarded to make way for the more pressing demands occasioned by the war; while in other lines exigencies accelerated development. Many companies have been handicapped through loss of skilled labor and operatives in the face of increased production demands. Moreover, it has often been difficult to obtain the desired quality of material, and labor shortage, together with inability to secure delivery of new equipment, has often rendered proper maintenance difficult.

Another factor of utmost importance is the increased cost of fuel and labor, both of which are here to stay. This calls for closer attention to operating economies and the attaining of more favorable load conditions. It also emphasizes the necessity for greater water-power development, the lack of adequate legislation regarding which has been so costly to the nation during the last few years. With a definite solution near, the closing days of the Sixty-fifth Congress again shattered hopes for early development when it let die a bill that was generally acceptable to all interests concerned. Will the performance be repeated by the new Congress or will it be spurred to action by the coal situation? Meanwhile the attitude of Secretary Lane is most encouraging. His plan for a survey of the power situation in the New England and Atlantic States section and the scheme for "Regional Power Systems" as outlined by George Otis Smith, Director of the Geological Survey, give promise of closer coöperation between the Government and central-station interests in solving the power problem.

Our many readers in large power stations particularly will find much of interest and value to them in the article on Holtwood record keeping elsewhere in this issue. The excellence of service from this large hydro-electric plant supplying power to Baltimore, Maryland, and Lancaster, Pennsylvania, is due in no small measure to the methods of recording, filing and checking data on the operation and condition of the station's equipment. It is not practicable to standardize record and report forms, but one wonders if there is excuse for the wide variety of forms found in plants similar in character. Of all the forms we have seen, certainly none were better suited to a plant than those at Holtwood. We believe many of them are applicable in other stations, hydro-electric and steam.

In his discussion of the Diesel engine in this issue, Mr. Sprado lays stress on the importance of employing high-grade men to operate them. This statement, which reflects the present view of prominent builders of this type, is most gratifying and in accord with the stand that *Power* has always maintained; although it will be recalled that four or five years ago certain other builders took quite a different view and were quick to resent such a statement. It goes to prove that an experienced and intelligent operator is one of the best assets toward establishing a good reputation for any piece of power-plant apparatus, and particularly a Diesel engine where small clearances, high pressures and high temperatures are encountered.

Regarding the difference in steam consumption in a heating system when using either exhaust steam or live steam at reduced pressure, considerable difference may be had in the results due to the design of the system. Therefore the man who claims that he burns as much coal to heat a building using live steam, and the engine shut down, as he does when using exhaust steam with the engine running, may be as correct in his conclusions as the engineer who claims that less steam is used when he utilizes the exhaust from his engine.

Dealers are very much concerned and the Government is very considerate lest the releasing of some of the surplus supplies that it accumulated should break the high prices at which the goods are at present held; but we did not notice any such concern or precaution against inflation of the price to the consumer by the exceptional demand at the time that they were bought.

It is not within the power of the human machine to turn out continuously as much work in a thirty-hour week as in a forty-four-hour week. Therefore to keep up production to meet the world's needs, increasing use must be made of machinery. This being the case, the future promises plenty of activity and opportunity for the engineer.

Correspondence

Loose Connection Causes Motor Troubles

A 10-hp. 500-volt direct-current motor was giving trouble owing to the fuses blowing, but the cause could not be found. A circuit-breaker was installed in place of the fuses, but the shop was still frequently shut down, which showed that the trouble had not been removed. The motor and the starting box were taken to a shop and were given what was supposed to be a complete overhauling. When they were reinstalled and tested, the armature started very slowly and the starting-box resistance became very hot, which indicated that the field circuit was apparently open. The starter was opened up and the field circuit was found to be connected as shown at *B*, in Fig. 1. Since practically all the line voltage is absorbed in the starting resistance when the starting-box handle is on the first contact points, the voltage across the field coils is very low, hence the field current is very small. This caused the armature to develop practically no torque or pulling power, which accounted for its slow speed and the heating of the starting resistance.

By changing the field connection inside of the starting box to that at *B*, Fig. 2, the starter trouble was relieved and the motor was again put into service. In a short time the circuit-breaker opened again and caused the plant to be shut down. This showed that the trouble had not been corrected.

A study of the conditions indicated that the motor showed no bad effects and the breaker did not open from a short-circuit, but that the trouble was apparently caused by a loose connection, which opened the line for a few seconds and closed it again before the starting-box handle returned to the off position.

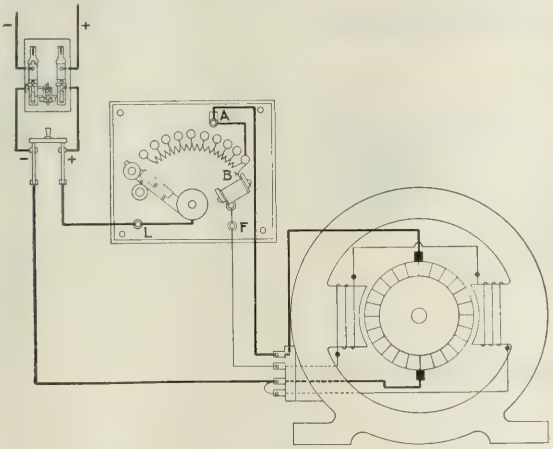


FIG. 1. SHOWS WRONG CONNECTION IN STARTING BOX

A voltmeter was connected across the switch as in Fig. 2, and watched for a drop in voltage before the breaker opened. If the voltmeter had showed a drop, the trouble would have been between the switch and source of power. But the voltage was steady, hence the trouble was between the switch and the motor. Starting at the switch all connections were examined. The armature leads were held in brass terminals by setscrews. One of these screws had worked loose, thus permitting the circuit to open momentarily at this point due to vibration. The joint was covered with tape, which held the lead in place and also made the trouble difficult to locate.

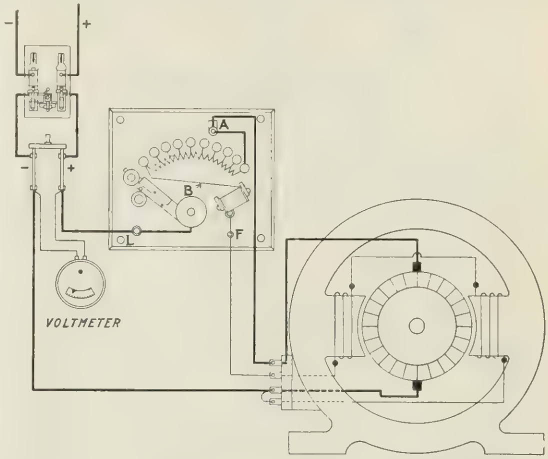


FIG. 2. STARTING BOX CORRECTLY CONNECTED

R. L. HERVEY.

Washington, D. C.

Generator Heats Excessively

In my letter, "Generator Heats Excessively," in the Feb. 11 issue of *Power*, I did not intend to create the impression that it is necessary for the armature to rub on the polepieces to cause heating, since the unequal air gaps alone are enough to produce the trouble; the greater the difference the greater the heating. I am writing from personal experience, as I had this trouble two years ago.

I have charge of the heating and lighting plant at Huron College, and we have a 50-kw. direct-current generator directly connected to a 12 x 12 engine, the main bearings of which became so badly worn that in taking up the lost motion with the wedges the armature was drawn over until it did not lack more than the thickness of a sheet of paper of touching one of the polefaces. The generator was a six-pole compound-wound machine, and the pole nearest the armature became so hot that I could not hold my hand on the yoke; and as I could not shut down to make repairs at that time, I cut out the shunt winding on this pole and, by allowing the main bearing to run a little loose, got through the season without serious trouble.

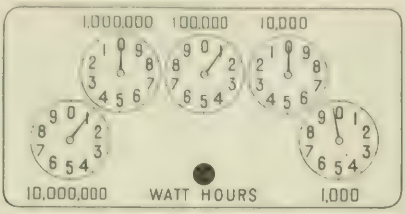
We rebabbitted the main bearing the following fall, and the generator has been running satisfactorily ever since.

JAMES N. CHALLACOMBE.

Huron, S. D.

What Does the Meter Read?

The article, "How to Read the Watt-Hour Meter," by Victor H. Todd, in the issue of March 25, has created considerable interest among the fellows around our plant, in reading watt-hour meters. However, the dial arrangement shown in the figure is one that we have not been able to agree upon as to just what the correct reading is. I am therefore submitting this problem to the readers of *Power*, thinking that some of them will give the correct reading and the reason for their interpretation.



WATT-HOUR METER DIAL

Charles A. Armstrong.

Philadelphia, Penn.

Firing-Door Arch Construction

Brick linings at the sides of the furnace fire-doors had to be replaced frequently due largely to being broken by fire bars and cleaning tools. A pattern of 1-in. pine board was made as shown in Fig. 1, and castings were made the width of the deadplate and the height of the brickwork at the sides of the fire-doors, in this case about 14 in. The slanting notch and the projecting piece at the top were to hold the ends of the cast arch bars which extend across the fire-doors and support the front arch bricks. This notch prevented the arch bars from creeping toward the fire. The bars were about 1 in. thick and 5 in. wide. By drilling a ⅝-in. hole in each end in the flat part and slipping in a bolt two or three inches long, the plates were prevented from moving. Before using these plates, the front arch had to be relaid once or twice a year, but the plates lasted two or three years, and, until they were burned back too far to hold the arch bars no relaying of the arch was required.

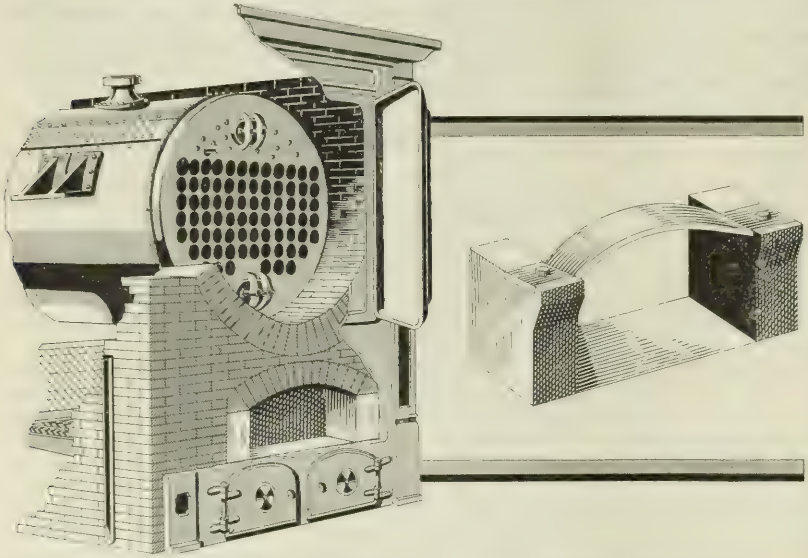
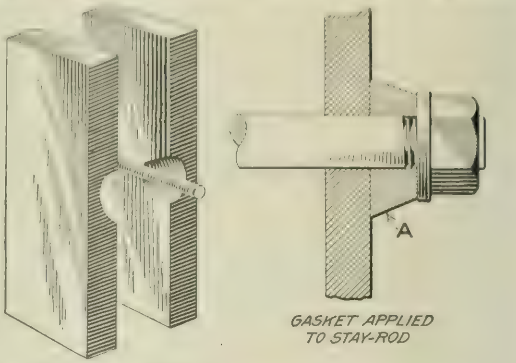


FIG. 1. APPLICATION AND DETAILS OF ARCH BAR AND SIDE PIECES

A leak would sometimes occur around the long through rods which extend from end to end of the return-tubular boilers. After trying several kinds of gaskets, such as asbestos, wire gauze, red lead and iron filings without satisfactory results, a mold was made of two pieces of boards clamped together and a hole bored through them in the center the size of the through bolt, then cut out each half tapering about ½ or ¾ in. deep, as shown in Fig. 2. A piece of tube or pipe was then placed in the hole the size of the rod and all clamped in a vise and lead poured in the mold, which made a tapered lead gasket as shown at *A*. This gasket was slipped on over the rod with the large washer, and when the nut was screwed up tight the leak was permanently stopped.



GASKET APPLIED TO STAY-ROD

MOLD FOR LEAD GASKET

FIG. 2. MOLD AND APPLICATION OF LEAD GASKET

Trouble was also experienced with the cast-iron collector rings on the alternator, due to burned spots on them equidistant between the brushes. As the rings are case-hardened, it was almost impossible to smooth them up. An old wire-gauze alternator brush was sawed down to the size of the carbon brushes on the rings, and one was put on each ring in place of the carbon brush. As a result in a short time the burned spots had disappeared and then the metal brushes were replaced with the carbon until the rings began to spot again. The metal brushes will run somewhat hot, but they will true up the rings.

Many methods have been employed in truing up burned rings. My way is so simple that anyone can use it without the expense and trouble of making apparatus to do the job.

Le Roy Miller.

Sodus, N. Y.

Hand-Damper Regulation Bonus

On page 328 of the Mar. 4 issue is an article by John F. Hurst, on "Hand-Damper Regulation." I am a firm believer in the uptake control, and where a firm or company is so poor or penurious that they cannot or will not purchase a good damper regulator, the idea of P. Henwood, published in a previous issue, is all right, but the best fireman in the universe cannot regulate his draft at all times as nicely or efficiently as will a good hydraulically operated regulator.

I had an opportunity a few years ago to see this nicely demonstrated. The fireman was an exceptionally good man and tried his best to get results, but in spite of his good will and best endeavors, the safety valve would blow occasionally and steam would drop a little at times.

The engineer was also the machinist for the shop, and so the fireman oiled the engine and pumps. One day as I was passing, the "old man," as we all called the fireman, asked me what I thought of the idea of operating the damper automatically and I told him that almost anyone who made any pretense of being bright had done that trick for some years.

"Do you do it?" he asked me point blank, and I don't know to this day whether he meant it for a joke or otherwise, but I told him that I had an ancient edition that did not regulate within 8 pounds.

He told me that the makers of a certain regulator guaranteed it to hold steam within one pound and that his company was going to give it a test. The regulator was installed and McNally gave it a test. He fired as faithfully as he knew how and they weighed the coal; a water meter was on the boiler line.

This line supplied the faucet at the sink and the hose connection for wetting the ashes and then fed through a closed heater into the boiler. A feed pump could be put in operation if the town pressure fell below a certain point, which it did at times.

The meter was always read once a week, on Sunday, so they knew approximately what the boiler was doing.

The boiler was operated the first week with the new regulator working as nicely as they guaranteed. The next week the boiler was fired without the regulator working and the fireman did his level best to beat the regulator, but he fell short by several hundredweight of coal, and the water meter showed a little more water used the week the regulator was operating; but the regulator was taking from the line, which accounted for some of the water used.

Several tests were made and the saving appeared to be about 3½ per cent. The agent who placed the regulator on trial had guaranteed at least 5 per cent. and he said it might show 10, so of course he was disappointed, but anyone that knew McNally was not surprised.

Even at 3½ per cent. the regulator was a paying investment, so it stayed in the plant, but it would have shown 10 per cent. saving in fifty plants out of a hundred and probably 5 to 8 per cent. in 75 plants.

I believe in paying my firemen the highest possible wages, as well as my engineers, oilers, helpers and repairmen—with no bonus. We make cloth of varying weights and textures and cannot draw a fine line nor split a coarse line. If, after paying my men the limit, they must have a bonus to do good work, I simply drop them. I firmly believe bonus systems in a plant lead to crooked work that more than offsets the good they do.

In one plant with which I am more or less acquainted at stock-taking time the coal was always accurately estimated from the daily log, but six months after a bonus system was tried the coal fell short of the estimate by 400 tons.

The bonus system had shown a saving of 12 per cent. Stock taking showed a loss of just the amount of bonus paid. The coal consumption was neither more nor less than for the same period of the previous year, notwithstanding that the water evaporation was higher—apparently. No more product was shipped from the plant, the same amount of fuel was purchased as formerly, the grade was the same, and the only difference was a bonus paid that was not earned and a rupture caused that eventually cost the chief engineer a mighty good berth.

If I am in doubt as to whether a man who is paid by the hour has worked three or four hours overtime, I give him four and also pay time and a half. If my salaried men, who are allowed two weeks vacation per year, are sick one or two weeks, I don't call that their vacation nor deduct from their salary, but the man who tries to put something over has got to do it in such a nice refined way that I cannot detect it or he has lost his job, and the men know it.

A man who works for me will get any bonus on his merits by a raise in salary if the plant can afford it, and my men must be far enough advanced in their craft to be able to get results without signs to warn them how to do it.

Many times the fireman is referred to in an unbecoming way, which he does not deserve, and his intellect is questioned, but it is a wrong proceeding, and many a man behind the shovel or at the stoker has got just as many ounces of gray matter as the man on watch in the turbine room, and, incidentally, many a chief engineer started on the end of a coal scoop.

New York City. C. W. Peters.

Safe Loading of Two-Phase Cables

In the loading of three-wire two-phase cables where all three conductors are the same size, the current in the center wire frequently is not considered. In a three-wire cable carrying a balanced two-phase load, the current in the middle wire is $\sqrt{2}$, or 1.41, times the current in the outside wires; so that the capacity of the middle wire is the determining factor in the loading of the cable.

As the ammeters are always placed in the two outside wires, it is very easy for the operator to neglect the current in the middle conductor. For this reason the capacity per phase of such cables should be computed for the current in the middle wire. Thus a three-wire two-phase cable rated at 300 amperes per conductor should carry a full-load current per phase of only $\frac{300}{\sqrt{2}}$, or 213 amperes.

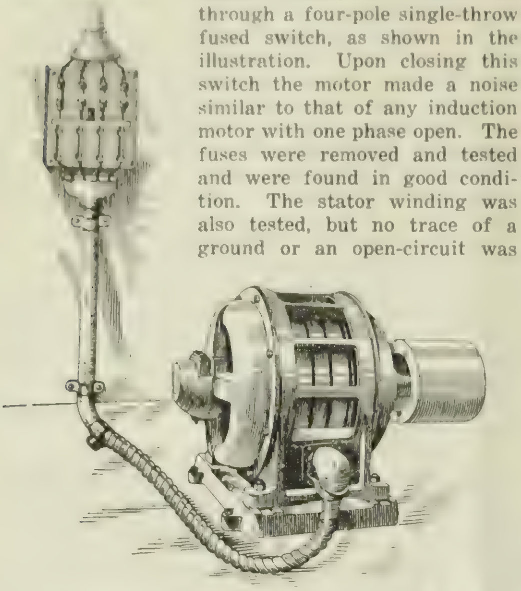
In the relay settings this same consideration must be made where, as is usually the case, the relays are connected only to the outside wires. Thus, if the 300-ampere per conductor cable were to be protected for 100 per cent overload, the relays should be set for $2.0 \times \frac{300}{\sqrt{2}}$, or 426 amperes, instead of 600 amperes.

Philadelphia, Penn. F. J. Gillooly.

Induction Motor Failed To Start

A two-phase four-wire four-pole 500-volt induction motor used to drive a small freight elevator failed to start when the switch was closed. No starting device was used with this motor, the stator winding being connected directly to the line through a four-pole single-throw fused switch, as shown in the illustration. Upon closing this switch the motor made a noise similar to that of any induction motor with one phase open. The fuses were removed and tested and were found in good condition. The stator winding was also tested, but no trace of a ground or an open-circuit was found. Upon questioning the attendant he said that he had opened the fuse clips a small amount so that he could remove the fuses easily. Upon replacing the fuses it was found that one of them was held tightly by the bottom clips, but a very small air space remained between the upper ferrule and the top clips. Thus, when the switch was closed the motor was placed across the line with one phase disconnected. Upon tightening the clips, the motor was started without further trouble.

Jersey City, N. J. JOHN H. SHAVER.



ARRANGEMENT OF MOTOR INSTALLATION

Qualifications of a Diesel Operator

Much credit for smooth operation of Diesel engines is due, naturally, to the operating engineer. A certain author in a book on Diesel engines, comparing them with gas and producer-gas engines, stated: "In this respect the Diesel engine differs from other prime movers in that its over-all fuel economy is not dependent on the efficient operation of auxiliaries, or even on the skill of the operators, as its operation is largely an automatic thermodynamic process in the engine itself. With a correctly designed and efficiently built engine this economy will be maintained undiminished during the life of the engine, provided the engine receives proper care."

Now, unless the operator is a skilled mechanic, he cannot give the Diesel engine the proper care its importance in the world of power demands. The engine requires considerable attention. Joints must be ground in to perfection to prevent leakage of air, for it requires but a small leak to cause loss of pressure.

The pressure varies from 800 to 1200 lb. per sq.in. Some gages are marked in atmospheres and others in pounds. The pressures to be used vary with the load carried, the highest existing at heavy loads, and they are regulated by the engineer by throttling the inlet to the air compressors, by bleeding the air bottles and sometimes by setting an auxiliary safety valve.

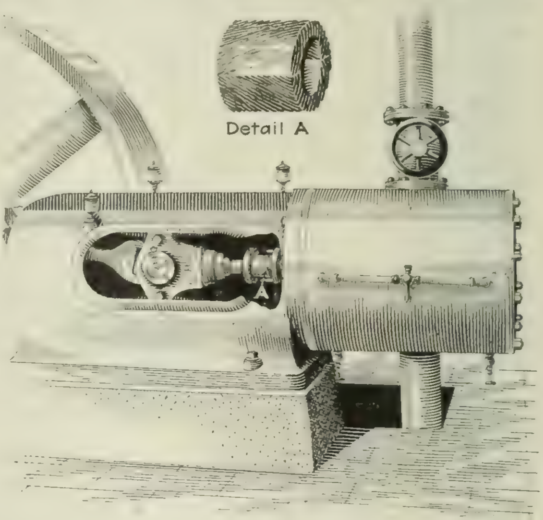
An unskilled operator will gradually become skilled, but while doing so he will cost money and will cause some unavoidable shutdowns and fuel losses. The skilled man will save money in fewer repairs, higher operating economy and reliability of operation during working hours, and the higher the grade of the man the better the over-all efficiency up to the maximum obtainable. The old story that the oil engine or gas engine requires no skilled operator has never had much of a chance to impress the erecting man. It has been exploded many a time. D. L. FAGNAN.

New York City.

Packing a Piston Rod

I use the following method in packing piston rods with fibrous metallic packing. It is necessary that the rod be smooth and running true to use such packing successfully.

I secure a wooden bushing, such as is used with wooden pulleys, which exactly fits the stuffing-box and rod, put in a small amount of packing at a time, place the bushing in the stuffing-box, jam it home with the gland, and repeat this until the stuffing-box is full. Then I jam the gland against the packing until it sets to conform with the shape of the gland. Frequently the distance between the oil splasher and the stuffing-box is very short. In such cases it will be necessary to saw the bushing off as the stuffing-box fills with packing. Do not attempt to jam the packing in with the gland, as it will not stay square in the stuffing-box.



USING WOODEN BUSHING WITH FIBROUS METALLIC PACKING

Kansas City, Mo. E. J. SCHAEFFER.

The *Locomotive*, published by the Hartford Steam Boiler Inspection and Insurance Co., lists 39 flywheel explosions as having occurred during the year 1918. Up to and including September of the same year it records 314 boiler explosions.

Inquiries of General Interest

Too Much Blowdown of Safety Valve—If a pop safety valve that was set at 90 lb. is adjusted to blow at 70 lb. and the valve does not shut off until the steam pressure of the boiler drops to 60 lb., what should be done? H. A.

Safety valves of boilers carrying an allowed pressure of less than 100 lb. per sq.in. gage should close after blowing down not more than 4 lb. If the safety valve, when set to blow at 70 lb., does not close until the steam pressure falls to 60 lb., thereby allowing 10 lb. blowdown, the blowdown should be adjusted so the valve will close at not less than 70 − 4 = 66-lb. pressure.

* * *

Travel of Cylinder Over Piston—I claim that at times the cylinder of a locomotive travels over the piston, while B and C claim it would be impossible. Which is right? F. J. S.

Motion of a body is change of its position with reference to the position of a point, a line, or another body. Regarding a railroad track as a stationary object to which motion of the parts of a locomotive are referred, when the locomotive is going forward, the cylinder is carried forward at the speed of the locomotive, and during a stroke of the piston from the head end of the cylinder, it is not moving forward as fast as the cylinder and the cylinder may be said to pass over the piston in the same way that a boy might make a running jump and pass over the head of another who is walking slowly in the same direction.

* * *

Equivalent Evaporation at Different Feed-Water Temperatures—How many pounds of feed water at 212 deg. F. evaporated into steam at 70-lb. gage pressure would be equivalent to the evaporation of 30 lb. of water from a temperature of 100 deg. F. into steam at the stated pressure? J. R. C.

A pound of steam at 70-lb. gage pressure, or 85 lb. absolute, contains 1183.4 B.t.u. above 32 deg. F., and evaporation of 30 lb. of feed water from a temperature of 100 deg. F. into steam at 70-lb. gage pressure would require $[1183.4 - (100 - 32)] \times 30 = 33{,}462$ B.t.u. For evaporation from a temperature of 212 deg. F. into steam at 70-lb. gage each pound of feed water would require $1183.4 - (212 - 32) = 1003.4$ B.t.u., and to obtain an evaporation into steam at 70-lb. gage pressure equivalent to conversion of 30 lb. of feed water from a temperature of 100 deg. into steam at 70-lb. gage pressure would require the evaporation of $33{,}462 \div 1003.4 = 33.35$ lb. of the feed water at the temperature of 212 deg. F.

* * *

Determining Lap and Lead of D-Valve—How can the steam lap and lead of a D-slide valve of an engine be determined without removing the steam-chest cover? E. M.

Make a mark on the valve stem at the end of the stuffing-box gland when the stem is farthest in, and another when it is farthest out of the stuffing-box, and halfway between these marks locate another mark to represent the mid travel of the valve. Then turn and block the engine wheel to such a position that steam will be just admitted to one end of the cylinder with the throttle valve open only a little, as shown by the escape of steam from the open cylinder pet-cock on the same end of the cylinder. Make a mark on the valve stem at the end of the stuffing-box gland and locate a similar mark with the valve just opening on the other end. The distance between these latter marks will be equal to the sum of steam laps of both ends of the valve, and the distance that each one is from the mark previously made to register the mid travel will be the amount of steam lap on corresponding ends of the D-valve. To determine the lead at either end, place the engine on a center and make a mark on the valve stem at the end of the stuffing-box. Note the distance of this mark from the mark made for registering the beginning of opening of the same end of the valve. If the engine would have to be turned backward to obtain the registration of the opening, then the distance so noted would be the amount of positive lead, but if it would have to be turned forward, the distance would be the negative lead, or amount the valve would lack of being open at the beginning of the stroke.

* * *

Shell and Core Type Transformers—What is the difference in construction in shell-type and core-type transformers? K. B. A.

In the shell-type transformer the coils are assembled and then the core is built up, of thin sheets of soft iron, around the coils, as shown in Fig. 1; and in the core-type the coils are placed around a core built up of thin sheets of soft iron in the form of a square link, as shown in Fig. 2. The arrangement shown in Fig. 2 is the one generally used for core-type transformers, and the one given in Fig. 1 is only one of a number of arrangements for the core and coils of shell-type transformers, but they all follow the general idea set forth in this figure.

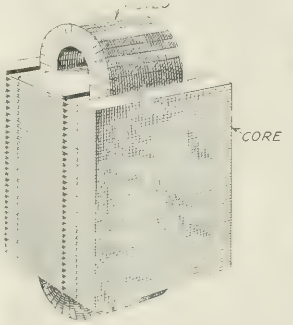


FIG. 1

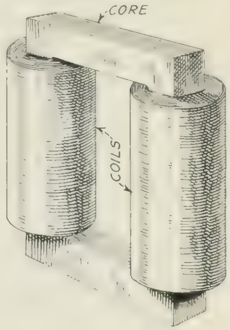


FIG. 2

* * *

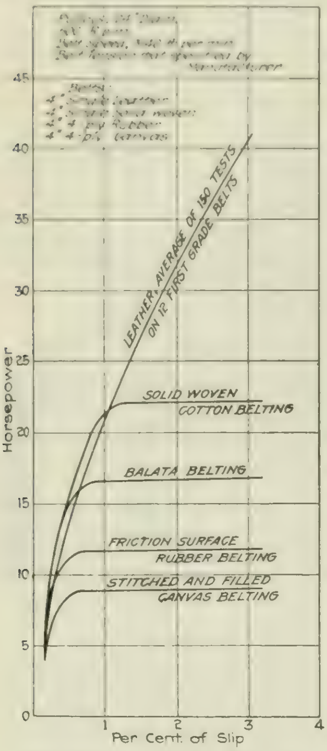
Data for Ordering Pinion—If the pinion to an elevator should be broken beyond repair, what data should be sent to the factory to secure a wheel to replace the broken one? W. H.

When ordering of the maker, state the purpose of the wheel, and give the pattern number if it bears one. The order should state whether a cut or cast gear is to be supplied. Give an accurate measurement of the working distance between the center of the pinion and center of gear wheel with which the pinion meshes, and the number of teeth and outside diameter of each, and furnish a drawing or templet the shape of a segment of the gear wheel that will include eight or ten teeth, showing their shape marked off from the wheel on a sheet of tin plate or cardboard, and state the desired width of face of the teeth for the pinion. Also state the length of hub, how much each end of the hub is to be offset under or beyond the teeth; whether ends of hub are to be finished, diameter of bore, size of setscrew, size of keyway in shaft, whether new key is wanted and from which end of the hub key is to be driven.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Comparison of Belt Materials

Everyone who has had experience in the use of belting for power transmission has in a general way decided upon the relative merits of various types of belts and belt materials. Since each drive has its own characteristics and difficulties, there is a lack of agreement among the users of belts as to just what the various types of belting will do, and it was to supply this information that the investigation[1] was started.



RELATION OF BELT SLIP TO HORSEPOWER

Tests were made with various types of pulleys, all of which are in everyday use. While different results were obtained with different pulleys, the ratios between the various types of belting materials remained the same. That is, although leather on paper pulleys showed higher results than on iron, so also did balata and rubber, and the advantage of leather over other materials remained unchanged.

In all tests the pulleys used were 24 in. in diameter, some were crowned and some straight face. In the series of tests on the first set of machines the belt was run at 3770 ft. per min., while in the series run on the second set of machines the belt speed was varied from 2500 to 5000 ft. per min. Most of the tests were made at 500 r.p.m., or a belt speed of 3140 ft. per minute.

Tests were made at a number of tensions in order to determine whether or not the relative capacities of the belts changed with changing tension. The light running tension varied from 35 to 75 lb. per inch of width, which corresponds to approximately 45 to 90 lb. per inch of width when the belt is standing still. The difference between the tension of the belt standing still and running under no load is due to centrifugal force. Most of the data here presented are based on tests in which the tension was a little higher than that advised by the manufacturers of the various belts, and ranged from 50 to 70 lb. per inch of width when the belt was standing still.

The tests were conducted by increasing the load on the belt from zero to a point where the slip amounted to at least 3 per cent. and the belt showed signs of distress. Measurements of speed, tension and horsepower were made at each step. The horsepower transmitted by the various belts at different percentages of slip is shown in the illustration.

The curves show that fabric belts all possess a definite maximum beyond which it is impossible to go, and that the points of maximum power-transmitting capacity are below the safe load for leather belting. The leather belts at this speed are rated from 20 to 25 hp. The curves show that leather belting operating at 25 hp. has an overload capacity of 60 per cent., while not one of the fabric belts, operating with no factor of safety at all, can carry such a load. While it would not be advisable to operate belts at their full capacities, it is important to know just what margin is available for overloads.

The results of these tests indicate the following:

1. Leather belting possesses a much greater power-transmitting capacity than fabric and in the ratios shown in the illustration.

2. The enormous advantage of leather over all the substitute belts persists at all speeds up to at least 5000 ft. per min., and at all tensions within the range practicable for power transmission.

3. The relative capacities of the various belts remain the same on various kinds of pulleys.

4. Leather belting, at its rated horsepower, possesses a big overload capacity, while the fabric belts at much lower horsepower possesses no overload capacity whatever.

5. Leather belting improves with age, while the fabric belts are at their best when new.

6. Wherever a fabric belt of a given width is carrying its load with some degree of success, a suitable leather belt three-quarters as wide will do better work than the fabric.

Leather is peculiarly suitable as a material for belting. It has great tensile strength; it is tough, pliable, flexible and practically indestructible. There are in existence pieces of leather that are known to be hundreds of years old, still strong and full of life. Time has no effect on its chemical construction. Water or dampness does not injure it, and it does not rust, corrode, crystallize or disintegrate. It is injuriously affected only by certain acids, and it wears slowly from the results of friction. A leather belt. properly proportioned to its work and of a suitable character, will give service for a long time with reasonable care.

Should a leather belt outlast its first installation, it may be cut to a narrower size, shortened or lengthened and the remodeled belt is as good as ever. When it has become old and beyond the repairing ability of the mechanic of the shop, it can be rebuilt by its maker, the bad places cut out, the good retained, and sufficient new added to make the proper length. It is then good for many more years of usefulness. When repairs become inadvisable, it still has a value for repairing other old belts, or for straps, brake shoes, heel taps, etc. The last remnant of it is worth something to somebody.

None of these statements is true of the substitutes for leather belts. They cannot be cut down into other sizes, repaired or rebuilt, and when finally discarded they have no salvage value. Some of these belts have a low first cost and others approximate the cost of the leather belt; but all of them, calculated on a basis of the cost of transmission per horsepower per annum, will be found to cost many times the price of the best leather belts.

In a paper on boiler mountings recently contributed to the Liverpool Engineering Society, J. Purves describes an unbreakable water gage. It consists, says *The Engineer*, of a perforated metal tube, and replaces the $\frac{3}{4}$-in. glass tube in an ordinary water-gage mounting. The diameter of the holes is $\frac{1}{32}$ in. On the gage cocks being opened water issues from the hole below the water line in the form of a rapidly diverging white cloudy spray, well defined and readily distinguished. Steam, on the other hand, which issues from the holes above the water line, is only faintly visible and is hardly discernible. The steam jet is almost parallel and quite distinct in character from that of the water; a definite indication is therefore assured. The character of the water jet bears a distinct relation to the thickness of the wall of the tube; by reducing the thickness of the tube, the jet can be made to assume wider proportions. Good results are obtained by thinning the tube down to $\frac{1}{32}$ in. round a $\frac{1}{32}$ in. diameter hole. Much smaller holes than these, however, will give a perfectly visible jet.

Frank H. Probert, consulting engineer of the United States Bureau of Mines, says that the destruction wrought by Germans in northern France was so "systematic and diabolical" that it will require five years to rehabilitate the coal, iron and steel industry and from 12 to 15 years to return the mines and mills to normal output.

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[1] Investigation conducted at the Mellon Institute of Industrial Research, Pittsburgh. This abstract is based on the data thus obtained, as sent out by the Leather Belting Exchange, Philadelphia.

Chicago N. A. S. E. Entertain National President

On his way home from California to the 1919 convention city, Huntington, W. Va., Roderick MacKay, president of the National Association of Stationary Engineers, stopped off at Chicago and attended a meeting of local No. 28 on the evening of May 3. As a directors' meeting had been called for the same date, the Chicago association had the unique honor of entertaining all of the national officers. The return of the president was timed to attend the weekly meeting of No. 1 on May 6.

Mr. MacKay said that he had been impressed favorably with the preparations for the annual convention. The Chamber of Commerce was active and enthusiastic, the city was of about the right size and the convention hall an excellent place for the meeting. Reviewing the affairs of the association, he stated that the organization was in good financial condition due to the increasing prosperity of the official paper. Membership was not so satisfactory. There had been some decrease in the last year or two, but this had been due to the unusual conditions. The president favored isolated membership, particularly in the Western States, where distances between locals were great. These men got the news of the association from the official paper and, when they moved to a city having a local, at once became active members. He also favored junior membership. Get the young man early so that he will become an active member automatically. His enthusiasm and energy are needed, and he in turn will be benefited by the older heads. A firm believer in honorary membership, Mr. MacKay pointed out the mutual advantages of having the employer with them and taking an interest in the work.

"Dad" Beckerleg, the first president of the association, made an appropriate response.

John Lane spoke of the welfare topics to be discussed at the coming convention and the innovation of receiving written discussion from any member to be read at the meeting.

The great interest being taken by the coal men in the coming convention was mentioned by Fred Raven. Already there were twenty coal exhibitors. With brief talks by Joseph O'Connell, John McGrath and Charles Naylor, complimentary to the present officers and trustees, the meeting was closed promptly to allow the national president to make an early start for Topeka, Kan., to attend the first state convention of the season.

Establishes Memorial Scholarships

As a proper war memorial to the more than 8000 employees of the Westinghouse Electric and Manufacturing Co. who entered the service of the Government in the great war, this company has decided to establish a number of technical scholarships. The details of the plan by which this will be done have been given out by President E. M. Herr as follows:

Four War Memorial Scholarships will be established each year under the following general conditions:

a. Candidates will be limited to sons of employees of the Westinghouse Electric and Manufacturing Co. and its subsidiaries, who shall have been employees in good standing for a period of five years.

b. Two of such annual scholarships may be open to the younger employees of the company or its subsidiaries who have been in their service for a period of at least two years and who do not exceed the age of twenty-three.

c. The selection is to be determined by competitive examination to be conducted annually by the company's educational department under the direction of the committee hereinafter provided. The examination is to take into account not only the applicant's academic training and preparedness, but due consideration will be given to personal qualifications, general character and aptitude.

d. Scholarships will entitle the successful candidate to pursue a four years' course in any technical school or college that he may select with the approval of the committee. The scholar may pursue a course in any branch of engineering that he may select.

e. Scholarships will be granted for one year only but will be continued for the full four years provided the scholar pursues a course in any branch of engineering that he may select.

f. Scholarships will be granted for one year only, but will be continued for the full four years provided the scholar maintains the academic and other standards required by the college or institution in which he elects to pursue his course of study.

g. Each scholarship carries with it an annual payment of $500 to be made in two installments and the number of new scholarships will be four each year.

h. A Memorial Scholarship Committee will be established consisting of three vice presidents of the company to whom shall be referred the names and records of the candidates and who shall select therefrom the four successful persons.

Data on Electric Light and Power Plants in Six States

The Bureau of the Census has given out some preliminary figures of the forthcoming report on electric-light and power stations in the various states for the five-year period, 1912-17. Statistics for six states may be summed up as follows:

The number of electric light and power stations in Alabama increased during the period covered from 69 to 82, 10 of the 13 additional plants being municipal and three commercial. The total income increased from $1,257,720 in 1912 to $3,152,709 in 1917, or 150.7 per cent., while the total expenses increased 195.4 per cent. Steam supplied the greater part of the primary power in 1912, but in 1917 56.3 per cent. of the power was derived from water. The aggregate dynamo capacity in 1917 was 128,509 kw., an increase of 425 per cent., as compared with 1912.

Georgia had 176 stations at the close of the period, as compared with 126 at its beginning, 40 of the 60 new establishments being municipal. The total income increased 75.1 per cent., the total expenses 63 per cent., and the aggregate horsepower 42.9 per cent. In 1917 the percentage of power derived from water was 59.8, as compared with 59.1 in 1912.

From 1907 to 1912 the number of establishments in Illinois decreased from 383 to 269, but by the close of 1917 they had increased to 303. Of the 34 new establishments in the period 1912-17, 22 were municipal. The total expenses in 1917 were $37,921,833, and the gross income, $46,245,976, the quinquennial increases being 61 per cent. and 53.9 per cent. respectively. Steam supplied 93.9 per cent. of the horsepower in 1917 and 93.7 per cent. in 1912. The total horsepower increased 62.1 per cent.

The 325 light and power stations in Iowa in 1917 brought in a gross income of $10,240,235, while the total expenses were $8,669,600, the increases over 1912 being 132.4 per cent. and 160.4 per cent. respectively. Water supplied 62.9 per cent. of the primary power in 1917; but in 1912, when there were only 223 plants in the state, 87.4 per cent. of the power was generated by steam. This change was due to the completion of the immense plant on the Mississippi River with dam and power house at Keokuk, Iowa. The increase of 815.3 per cent. in the output of current is also due to the starting up of the Mississippi River Power Co.'s plant, which distributes current not only in Iowa but in several adjoining states.

The statistics for Louisiana show an increase from 50 to 85 stations during the period 1912-17, 22 of the 35 new ones being commercial plants. The total income in 1917—$3,244,789—represented an increase of 42.4 per cent., while the total expenses — $2,459,868 — increased 53.4 per cent. Steam and internal-combustion engines supplied the greater part of the horsepower throughout the period, no water-power plants being reported.

Maine had 93 electric-light and power plants in 1917 as compared with 79 in 1912. Twelve of the fourteen establishments represented in the net increase were commercial, and two municipal. During the five-year period the total expenses increased 52.4 per cent. and the gross income 49.6 per cent. The increase in horsepower during the period was only 9.5 per cent.; water supplied 78 per cent. of the power in 1912 and 76.9 per cent. in 1917.

These statistics cover only municipal and commercial plants. The figures do not take into consideration any idle plants or plants in process of construction.

Engineer Discusses Niagara Power

At the regular meeting of the Detroit Engineering Society, Friday evening, May 2, the speaker, John L. Harper, chief engineer of the Niagara Falls Power Co., gave his audience an insight into the present installations and future development of power at the Falls.

Theoretically, the Falls could develop 6,000,000 hp.; in reality, only 3,600,000 is available, as 40 per cent. of the water would have to pass over the falls to keep the river clear of ice.

The speaker discussed the three principles upon which the governments of the United States and Canada base the amount of water that might be diverted from the Falls for power purposes: (1) The safety of the stream as a national boundary; (2) hindrance to navigation, causing Lake Erie to be lowered; (3) destroying the scenic beauty. His argument against the first item was that the people on the border had lost their fear of the "warlike" Canadians; second, that the water could be diverted for power purposes without affecting the level in Lake Erie by taking it from the pool immediately above the Falls.

In answer to the scenic beauty, he showed a picture of the beautiful American Falls, over which only 5 per cent. of the water flows. With this as a unit of measuring beauty, he suggests that the Horseshoe Falls be reduced to this flow. This would allow 80 per cent. of the water to be diverted for other purposes. However, the 40 per cent. of the water would necessarily have to flow over the Falls to keep the river free from ice, so the scenic beauty could not be destroyed by the power companies even should they divert all the water possible. Again, he brought out the point that something must be done to prevent the Falls from destroying themselves. Between the years 1764 and 1915, the brink of the Falls has retired 900 ft. and at the present time it is falling back at the rate of 10 ft. a year. Economically, he figured, basing the cost of power in terms of coal and distributing the cost of coal over the 1,000,000 visitors per year, that the waste power now added to the scenic beauty is costing $100 a look.

Regarding the scenic effect of the Rapids, it is generally conceded that they are more beautiful when the water is low, due to the more agitated condition of their surface. A peculiar thing was that 75 per cent. of the petitions to retain Niagara and its beauty were signed in the coal-mining districts.

Lantern slides were shown of the different methods used in developing the power, the different plants now operating and the construction of the 100,000 hp. addition to the hydro-electric plant below the Falls on the American side. The 100,000 hp. will be developed by three 33 to 37 thousand horsepower units. Each unit has a concrete base, 40 x 40 x 12 ft. thick, containing 60 tons of steel reinforcing. Great pains were taken to insure the greatest possible efficiency. The penstocks have a bell mouth to allow the water to gather speed before entering the comparatively smaller cross-section, the blades of the waterwheel are given the correct pitch to insure the maximum power and longevity, and the water which leaves the wheel has its velocity retarded from 20 to 4 ft. per sec., the pressure being converted into suction on the wheel. It is expected that a cubic foot of water will develop twenty-one horsepower in these units as compared with twenty in the old plant.

New Publications

EXPORT PACKING OF ENGINEERING MATERIAL

The Engineer Corps, United States Army, has recently compiled and issued an instruction book for export packing of engineering material. The matter contained in the book is the outcome of experience gained in the War Department during the war, where a great many diversified packing problems were encountered, in all of which it was necessary not only to protect adequately the articles shipped, but also to secure minimum space. The book is divided into seven parts: Part I covers Standard Crating Specifications of the War Department; Part II, Standard Boxing Specifications of the War Department; Part III, Standard Specifications for Wire-Wound Boxes; Part IV, Standard Specifications for Baling; Part V, Problems Encountered; Part VI, Supplementary Specifications for Packing for Engineer Material; Part VII, Standard Marking Specifications. Numerous illustrations of boxes and crates are given, and detailed directions for packing boilers, machines, switchboards, etc.

Personals

Joseph V. Santry, of the firm of Schumaker & Santry, of Boston, has been made vice-president of Combustion Engineering Corp., 11 Broadway, New York City.

George A. Harder has been elected president and a director of the Central Foundry Co., New York City, and its subsidiaries. Mr. Harder is also president of the Essex Foundry Co., Newark, N. J.

Lewis Nixon, state superintendent of public works of New York, has been appointed Public Service Commissioner by Governor Smith for the First District of Greater New York, in charge of regulation.

Stephen C. Pohe, who has been general manager of the Penn. Public Service Co. at Clearfield, Penn., has been appointed vice president of the operating companies controlled by the Pennsylvania Electric Co. of New York City, with headquarters at Johnstown, Penn.

William D. Ennis, who has, since his release from military service, been acting professor of mechanical engineering at Columbia University, has been appointed professor in marine engineering in the post-graduate department of the United States Naval Academy.

Lieut.-Col. John J. Swan, who has been connected with the Personnel Branch, Operation Division, of the United States General Staff, and more recently in the Classification Division of the Adjutant General's office, has resigned from the service to become associated with the Prest-O-Lite Co., of Indianapolis, Ind.

J. C. Rockwell has been promoted from local general manager to vice president of the Manila Electric Railroad and Light Co., Manila, Philippine Islands, in charge of the general Philippine affairs of that company. This property is under the operating management of the J. G. White Management Corporation, New York, N. Y.

R. Sanford Riley, president of the Sanford Riley Stoker Co. and the Murphy Iron Works, has returned to his private interests after having completed the organization of a performance section of the Emergency Fleet Corporation. The performance section has charge of all trial trips and follows up the defects developed in service.

Lieut. H. J. Williams, Engineering Division, Ordinance Department, U. S. A., Washington, D. C., has recently been discharged from the service and appointed engineer for the Beacon Falls Rubber Shoe Co., Beacon Falls, Conn. Before entering the service Mr. Williams was consulting and mechanical engineer in New York City and was also on the teaching staff of the Pratt Institute, Brooklyn, N. Y.

Obituary

George Lewis, of Brooklyn No. 8, National Association of Stationary Engineers, died Apr. 3 of pneumonia. Mr. Lewis was recognized as one of the most progressive members of the N. A. S. E. in the Empire State, being particularly identified with the educational activities of the Association. He was past president of Brooklyn No. 8, and at the time of his death was a member of the National Power Plant Costs Committee. He was a member of Melville Council of Universal Craftsmen, Commonwealth Lodge F. & A. M., and many other organizations. He was 42 years of age and held the position of chief engineer of the New York Consolidated Card Company, of Long Island City. He is survived by his widow and a daughter.

Engineering Affairs

Iowa's State Convention, N. A. S. E., at Marshalltown, June 11-13.

Illinois State Convention, N. A. S. E., will be held at Decatur, June 4-6.

New Jersey State Association, N. A. S. E., will hold its yearly convention at Bayonne, June 6-8.

Pennsylvania State Association, N. A. S. E., convention will meet at Pittsburgh, June 26.

Ohio State Association, N. A. S. E., will hold its annual convention at Youngstown, June 19-21.

Kentucky State Association, N. A. S. E., annual convention will take place at Louisville on June 18.

Canadian Association of Stationary Engineers will hold its annual convention at Brantford, Ont., June 24-26. An elaborate program has been arranged.

The Heating and Piping Contractors' National Association will hold its thirtieth annual convention in Atlantic City, N. J., June 12-14, with headquarters at the Hotel St. Charles.

Elmer E. Chambers Council No. 5 and the **Bronx Council No. 16**, of the Universal Craftsmen Council of Engineers celebrated a consolidation of the two associations on May 9 at the rooms of the Elmer E. Chambers Council. There was an entertainment and dancing, and refreshments were served. An orchestra composed of U. S. Navy "boys" furnished the music.

The Association of Iron and Steel Electrical Engineers, Chicago Section, will hold a joint meeting with the American Institute of Electrical Engineers on May 26, at the rooms of the Western Society of Engineers in the Monadnock Building. J. C. Wilson, assistant chief engineer of Cutler-Hammer Manufacturing Co., will give an illustrated lecture on "Measuring Gas Electrically," and B. E. Fernow, of the Cutler-Hammer Co., will give an illustrated lecture on "Lifting Magnet Operation."

The Kansas State National Association of Stationary Engineers held its seventh annual convention at Topeka, May 7-9. There were forty-five delegates present and about one hundred and fifty visiting engineers and ladies. The following officers were elected for the ensuing year: J. W.

Kessler, of Topeka, state president; **H. S. Dukes**, of Atchison, vice president; **C. H. Taylor**, of Topeka, secretary; **J. R. Stone**, of Fort Leavenworth, treasurer; **H. F. Thrift**, trustee. Topeka was chosen as the place to hold the next convention. In every way the convention was a big success, much of this success being due to the work of **Fred Painter**, chairman, and **J. M. Vansant**, retiring secretary.

Business Items

The Ohio Brass Co., Mansfield, Ohio, has moved its Chicago office from 508 Fisher Building to 1217 Fisher Building, 343 South Dearborn St.

H. W. Johns-Manville Co. announces the removal of its Denver (Colo.) office from the Denver Gas and Electric Building into more spacious quarters in the Iron Building, 1021 17th St., with Louis H. Inglee in charge.

L. V. Estes, Inc., industrial engineers and accountants, for a number of years located in the McCormick building, have removed to the Century Building, 202 South State St., Chicago, Ill., where they occupy the entire fifteenth floor.

The American Steam Conveyor Corp., Chicago, announces the appointment of N. B. Stewart as district representative in charge of its St. Louis territory. Offices have been opened at 708 Merchants-LaClede Building, St. Louis.

The Turner-Wagener Co., Inc., is the new name of what was formerly known as the Turner Advertising Co. J. H. Turner, who was president of the former company, is also president of the new organization. The offices are at 28 East Jackson Boulevard, Chicago.

The York Manufacturing Co. announces that its Philadelphia representatives, Central Construction and Supply Co., with main offices at 2222-26 Arch St., have opened a branch office at 9 West Redwood St., Baltimore, Md. The office is in charge of H. D. Green and John Hill.

The Black & Decker Manufacturing Co., of Baltimore, Md., has established a New York office at Room 2920 Equitable Building, which will be in charge of G. R. Lundane, who will supervise the distribution of the company's products in New York City and surrounding territory, including the State of Connecticut. Mr. Lundane was formerly connected with the Thos. B. Jeffery Co., Kenosha, Wis.

The Wayne Oil Tank and Pump Co., of Fort Wayne, Ind., has recently inaugurated a new consulting and advisory service for oil men, with F. A. Bean, consulting engineer, in charge of the work. Mr. Bean has had a broad engineering experience covering a period of 23 years, 15 of which have been in an executive capacity, and has been affiliated with the oil industry since 1902. The Wayne Co. invites all oil men to make free use of this service.

Trade Catalogs

The Smooth-On Manufacturing Co., Jersey City, N. J., has just issued a new and revised edition of "Smooth-On Instruction Book No. 16." The new edition, like its predecessors, of which hundreds of thousands are in use, is made up of helpful and interesting descriptions of engine and boiler-room repairs of all kinds. These are described by the men who made them in such a way that similar problems can be quickly and economically solved by other engineers. The book is well illustrated by actual photographs and drawings. A copy will be mailed free on request.

The Taylor Instrument Companies, Rochester, N. Y., has issued a general industrial catalog of Tycos instruments containing 422 pages of useful and interesting temperature information. This new publication describes the whole line of Tycos instruments for the indicating, recording and control of temperature. Many special applications are illustrated, showing the manner in which Tycos instruments can be adapted to diverse temperature needs. Practically every instrument manufactured by the companies for industrial purposes is illustrated, and much explanatory matter descriptive of their construction and principles of operation is given.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.75@3.25
Philadelphia, gross tons	4.27@4.95	5.95@5.50
New York, gross tons	4.62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7.90	Pea	4.90	6.65
Egg	5.95	7.80	Buckwheat	3.40	5.15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90@$3.25	$2.95@$3.50
Cambria County (good grades)	2.75@2.95	2.95@3.25
Clearfield County	2.50@2.75	2.80@2.95
Reynoldsville	2.50@2.75	2.75@2.95
Quemahoning	2.65@2.85	2.95@3.10
Somerset County (best grades)	2.65@2.85	2.95@3.10
Somerset County (poorer grades)	2.00@2.35	2.50@2.75
Western Maryland	2.25@2.75	2.50@2.75
Fairmont	2.00@2.25	2.35@2.50
Latrobe	2.10@2.25	2.25@2.40
Greensburg	2.25@2.35	2.35@2.60
Westmoreland	2.60@2.75	2.60@2.75
Westmoreland run-of-mine	2.35@2.60	2.35@2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.95	7.80	Rice	2.75	3.65
Stove	6.20	8.05	Boiler	2.50	3.50
Nut	6.30	8.15	Barley	2.25	3.15
Pea	4.90	6.50	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2.00@2.25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St. Louis is $1.07; other rates 92½c.

New Construction

PROPOSED WORK

Mass., Athol—The Union Twist Drill Co. will install a steam heating plant in the 4-story, 63 x 190 ft. office and storage building which it plans to build. Total estimated cost, $100,000. Frost & Chamberlain, Slater Bldg., Worcester, Arch.

Conn., Windsor Locks—G. P. Clark Co., Canal Bank, will install a steam heating plant and electric power in the 3-story, 60 x 185 ft. factory which it plans to build. Total estimated cost, $100,000. Ford, Buck & Sheldon, Inc., 60 Prospect St., Hartford, Engr.

N. Y., Athens—The town is having plans prepared by M. Vrooman, Engr., Gloversville, for the construction of a water system, water filters and pumping station, etc.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., will install a steam heating system in the 4-story, 100 x 144 ft. school which it plans to build on West 1st St. Total estimated cost, $299,500. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Brooklyn—I. Miller, 1663 Union St., will install a steam heating plant in the 2-story, 100 x 145 ft. theater which he plans to build at St. John's Place and Utica Ave. Total estimated cost, $150,000. T. Short, 370 Macon St., Arch.

N. Y., Brooklyn—J. Spielberg, 308 Sheffield Ave., has awarded the contract for the construction of a 2-story, 75 x 100 ft. theater which he plans to build on Stone and Pitkin Ave., to the Shoner Building Co., 149 Christopher Ave. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. Y., Brooklyn—The Stone Ave. Realty Co., 50 Court St., will install a steam heating plant in the 1-story, 100 x 100 ft. garage which it plans to build on Fulton and Hendrick St. Total estimated cost, $125,000. M. A. Canton, 373 Fulton St., Arch.

N. Y., Buffalo—The city will install an American Radiator system and two low water line boilers in the 3-story, 60 x 125 ft. detention home which it plans to build on East Ferry St. Estimated cost, $100,000. H. L. Beck, City Arch.

N. Y., Buffalo—The city will install an American Radiator system in the 2-story, 175 x 400 ft. barn which it plans to build on Hudson St. Total estimated cost, $300,000. H. L. Beck, City Arch.

N. Y., Holley—The Holley Cold Storage, Fruit & Produce Co. is in the market for ice-making machinery. Estimated cost, $6000.

N. Y., Jamaica—H. & J. Merkel, 450 Fulton St., Brooklyn, will install a steam heating plant in the 2-story, 75 x 100 ft. factory which they plan to build on Chichester Ave., here. Total estimated cost, $125,000. L. Allmendinger, 20 Palmetto St., Brooklyn, Arch.

N. Y., Long Island City—The Board of Education, 500 Park Ave., New York City, will install a steam heating plant in the 3-story, 100 x 108 ft. Public School No. 3 which it plans to build on Colonial Ave., between Livingston and Meter St. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., New Dorp—St. John's Guild, 103 Park Ave., New York City, will install a steam heating plant in the 3-story nurses' home which it plans to build here. Total estimated cost, $150,000. York & Sawyer, 50 East 41st St., New York City, Engr.

N. Y., New York—A. Brocener, Engr., 110 West 40th St., will install a steam heating system in the 16-story, 150 x 200 ft. hotel which he plans to build on 5th Ave., near 50th St. Total estimated cost, $500,000. Owner's name withheld.

N. Y., New York—The Hudson Motor Car Co. of New York, 1842 B'way, will install a steam heating plant in the 10-story, 100 x 100 ft. store and office building which it plans to build at 62nd St. and Amsterdam Ave. Total estimated cost, $550,000. E. J. Muller, 103 Park Ave., Arch.

N. Y., New York—The McCormick Co., Engr., 41 Park Row, will install a steam heating system in the 2-story bakery which he plans to build at 165th St. and Park Ave. Total estimated cost, $100,000. Owner's name withheld.

N. Y., New York—R. T. Rane, Jr., Chicago, Ill., will install a steam heating plant in the 4-story warehouse which he plans to build at 1996-2010 Park Ave. Total estimated cost, $175,000. Starrett & Van Vleck, 8 West 40th St., Engr.

N. J., Trenton—The Taylor Provision Co., Perrine Ave., plans to build a 2 story, 50 x 70 ft. refrigerator plant. Estimated cost, $20,000. J. O. Hunt, 114 North Montgomery St., Arch.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until May 26 for installing a high pressure air and water system at the Submarine Base here. Estimated cost, $43,000. Specification No. 3883.

Ala., Bessemer—The Board of Revenue of Jefferson County, Birmingham, will install a steam heating plant in the court house and jail which it plans to build. J. W. Gwin, Pres.

Ohio, Cleveland—The Arjo Realty Co., c/o J. Laronge, Williamson Bldg., will install a steam heating plant in the 5-story commercial hotel which it plans to build on East 66th St. and Carnegie Ave. Total estimated cost, $750,000. Lehman & Schmidt, 210 Electric Bldg., Engr.

Ohio, Cleveland—The Bricklayers' Association, 2416 East 9th St., will install a steam heating plant in the 3-story, 61 x 140 ft. garage and club rooms which it plans to build at 2101 East 21st St. Total estimated cost, $100,000.

Ohio, Cleveland—The Cleveland Heights Methodist congregation, Lee Rd. and Euclid Heights Blvd., will install a steam heating system in the 2-story church which it plans to build. Total estimated cost, $100,000.

Ohio, Cleveland—The Cleveland Masonic Clubs, East 6th St. and Superior Ave., will install a steam heating plant in the 3-story, 220 x 700 ft. Masonic temple which they plan to build at 3515 Euclid Ave. Total estimated cost, $500,000.

Ohio, Cleveland—The Eleventh St. Co., Williamson Bldg., plans to install a steam heating plant, in connection with remodeling the Lennox Building on East 9th St. and Euclid Ave., and building a new addition to same. Total estimated cost, $150,000.

Ohio, Cleveland—W. G. Montgomery, 1420 Alameda Ave., Lakewood, will install a steam heating plant in the 3-story theater which he plans to build on West 32nd St. and Bridge Ave. Total estimated cost, $150,000.

Ohio, Cleveland—C. Shane, c/o the Liberty Theater, 10315 Superior Ave., will install a steam heating plant in the 5-story store and office building which he plans to build on East 4th St. and Euclid Ave. Total estimated cost, $150,000.

Ohio, Cleveland—N. I. Stone, Rockefeller Bldg., will install a steam heating plant in the 4-story, 73 x 198 ft. theater and stores which he plans to build at 10618 Euclid Ave. Total estimated cost, $250,000. A. G. Yost, Rockefeller Bldg., Arch.

Ohio, Cleveland—W. Taylor & Son Co., Euclid Ave. and 6th St., will install a steam heating plant in the 9 story addition to its store which it plans to build. Total estimated cost, $500,000.

Ohio, Cleveland—W. Vretman, 413 Engineers' Bldg., will install a steam heating plant in the 2 story commercial building which he plans to build on West 117th St. and Lorain Ave. Total estimated cost, $125,000. Whitworth & Johnson, 413 Engineers' Bldg., Engr.

Ohio, Martin's Ferry—The city plans election Aug. 12 to vote on $450,000 bonds for new water works and electric lighting plant. C. Lash, City Engr.

Ohio, Stacyville—The Power Engineering Co., 510 Corn Exchange, Minneapolis, Minn., plans to build a new concrete dam and power plant here. J. A. Webber, Stacyville, Engr.

Mich., Battle Creek—The Advance Pump & Compressor Co., North Division St., is in the market for a centrifugal pump for heating systems. C. A. Flinn, Supt.

Mich., Detroit—The Detroit Seamless Steel Tube Co., Jefferson Ave. and 19th St., plans to build a 70 x 100 ft. heating plant including coal crusher and powdered coal system, in connection with the proposed manufacturing units on Warren Ave. Total estimated cost, $3,000,000.

Mich., Detroit—The North Woodward Methodist Episcopal Congregation, c/o W. E. N. Hunter, Arch., 1306 Chamber of Commerce, will install a steam heating plant in the 2 story, 180 x 250 ft. church which it plans to build on Woodward, between Marston and Chandler Ave. Total estimated cost, $500,000.

Mich., Detroit—The Woodward Theatres Co., 306 Breitmeyer Bldg., has awarded the contract for the construction of a 70 x 160 ft. theatre, store and office at 158-164 Gratiot St., to the F. Farrington Co., 202 Scherer Bldg. A heating plant, consisting of combination system with motor and fans, air compressors and sprinkler system will be installed in same. Estimated cost, $60,000. H. Koppin, Pres.

Wis., Sheboygan—The Congregational Congregation, c/o E. Hammett, 1209 North 7th St., will install a central heating plant to furnish heat for the 2 story, 90 x 150 ft. church which it plans to build on North 7th St. Total estimated cost, $100,000. W. C. Weeks, 720 Ontario Ave., Arch.

Ia., Mapleton—The city will soon award the contract for the construction of a pump house and laying pump suction line. Estimated cost, $8000. W. E. Standeven, 414 Bee Bldg., Omaha, Engr.

Minn., Hastings—The State Board of Control or C. H. Johnson, Engr., 715 Capital Bank Bldg., St. Paul, will receive bids until August 1st for the completion of a 1 story, 45 x 140 ft. power plant here. Estimated cost, $125,000.

Minn., Hibbing—The Oliver Mining Co., Wolvin Bldg., Duluth, will install steam heating equipment in the 6 story central addition to its commercial hotel. Total estimated cost, $200,000. S. S. Ramsey, Wolvin Bldg., Duluth, Engr.

Kan., Clayton—The city voted $10,000 bonds for the construction of a transmission line from Clayton to Norcatur.

Kan., St. John—The city voted $45,000 bonds to improve the water and light system by installing a power plant. Noted Feb. 11.

Kan., Topeka—R. L. Gamble, State Arch., will receive bids until May 27 for installing a vacuum steam heating and water supply system in the State Capitol building.

N. D., Hensel—The Village Board will soon award the contract for one 15 hp. force feed oil engine, one water tank suitable for same, one 50-gal. supply tank and one 10 kw. dynamo. L. J. Wilker, Village Clk.

Okla., Newkirk—The city plans election soon to vote on $110,000 bonds for the construction of electric light plant and service lines.

Ariz., Florence—S. M. Bailey, City Clk., will receive bids until May 28 for the construction of a water works and electric light plant. Estimated cost, $80,000. Noted Feb. 25.

Ore., Coquille—The Johnson Saw Mill Co. plans to electrify its plant and install two 75 hp. motors and one smaller motor.

Cal., Covina—The Covina Citrus Association plans to build an orange packing house and precooling plant to have a capacity of 80 cars daily. Ice plant machinery will be installed in same. Estimated cost, $125,000. W. W. Bennett, Mgr.

Cal., Modesto—The Modesto Gas Co. plans to build a new gas generating unit, install two new purifiers, build a 300,000 cu.ft. steel gas holder and extend gas mains to new section of the city. Estimated cost, $65,000.

P. I., Cavite—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until May 26 for installing power plant equipment here. Estimated cost, $90,000. Specification No. 3871.

CONTRACTS AWARDED

Conn., Hartford—Swift & Co., 60 North Market St., Boston, Mass., has awarded the contract for the construction of a 2-story, 78 x 100 ft. cold storage plant on Church St., here, to J. H. Grozier Co., 721 Main St. Estimated cost, $90,000.

N. Y., Utica—The Board of Education has awarded the contract for installing a heating plant at the J. E. Brandegee School to H. C. Petersen & Co., 20 Oneida St., for $16,973.

Que., Valleyfield—The Montreal Cottons, Ltd., 263 St. James St., Montreal, has awarded the contract for four 51-in. vertical water turbines of 50 hp. each, to operate with 12-ft. head at 100 r.p.m., to W. Hannetor & Co., 479 Reid St., Peterborough, Ont.

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SEE PAGES 77 TO 84

POWER

Volume 49 New York, May 27, 1919 *Number* 21

The Passing of the Boss

By Benjamin O. Wilkins

THIS is an age of rapid change. Things that have been familiar to us for years and customs that we have followed from youth are rapidly passing away. Among the old institutions that are now being numbered with the missing is the old-time boss.

The school of bossing is disappearing completely into the realm of the "things that were." We can scarcely realize, at times, that there ever was such an inefficient custom as "bossing" in current use. Yet such was the case; and most of us can remember the days when the head of the shop or office was not only called "the boss," but actually performed his function of supervising men by carrying out the idea of bossing to the limit. Not infrequently he did so with amazing genius for misunderstanding and with as little humor as the fellow that played the violin—"by main strength."

In the coming days of enlightenment and progress the man who is honored by being placed at the head of a group of men will realize that he is there to act as a helpful and stimulating influence. He will appreciate that he is given the position of trust and responsibility because he is judged by his ability to work *with* men rather than by the outworn and discredited standard that used to serve — the ability to make men work for him. He will be a coworker in the truest sense.

The most efficient leader nowadays is the man tnat is an inspiration and a guide to those who come to him for help. He is sought by the workmen because of his readiness and ability to furnish helpful information. Frequently, the worker feels the need of moral support in his tasks; so he goes to the man in whom he has faith and from whom he knows he will obtain the stimulus of encouragement.

From office, shop and factory comes the same report of the passing of the old régime — the boss is vanishing as an old-style dictator and is being supplanted by a new-style director. The successor is not afraid to put his hands to the work with his men, and his willingness to help lends encouragement and enthusiasm. The men are quick to sense his attitude and they respond by trying to save him petty annoyances and by showing a desire to do things more on their own initiative.

It is necessary that we adjust ourselves to such changes as these, which are for the benefit of us all. But to no one, perhaps, is the transition more difficult than to the old-time chief who is trying to conform to the new order. He needs our help and he deserves it.

The drivers of men have no place in the present industrial plan. The leaders of men have displaced them.

United States Nitrates Plant No. 2, Muscle Shoals, Ala.—Station Heat Balance

BY EDWARD R. WELLES* AND H. C. LOCKWOOD†

The hotwell water, which varies between 80 and 100 deg. F., is used for cooling the lubricating oil for the main turbine. This turbine is of 60,000 kw. continuous capacity and is electrically in parallel with two noncondensing house turbines which float on the line and furnish power for driving practically all auxiliaries in the station.

COMPETITION and the ever-increasing cost of labor and material have forced electric-power generating stations to utilize every available means to minimize their cost of power production. The two chief elements which form the basis of efficient power production are: First, station design and the arrangement of apparatus; and second, scientific operation and management. The latter is as important as the former, since poor operation may vitiate the natural advantages of the best-designed station. The design of the power house of United States Nitrate Plant No. 2 has been covered in previous articles. The purpose of this is to discuss and describe the operation of it.

With the accessibility of modern instruments and data, to attempt to operate any power-generating station without a complete detailed analysis of all station operations is the poorest policy. The steam generation of electric power is almost entirely a thermal process. The analysis of this flow of thermal energy in all its forms and functions from the coal pile to its final conversion into electric power is termed the station heat balance. By means of curves it shows the performance of all principal apparatus under all conditions and determines the most efficient points of operation. The heat balance also shows the expected and unavoidable losses in both position and extent and presents a criterion for all operation.

The following list of station apparatus has been considered in the heat balance:

1. Sixty thousand kw. unit, made up of three 20,000 kw. elements, consisting of a high-pressure element exhausting into two low-pressure elements, each of the latter being equipped with two 25,000-sq.ft. condensers.
2. Auxiliaries for 60,000-kw. unit consisting of four condensate pumps, four dry vacuum pumps, four circulating-water pumps, three blowers for generators, water pump for oil cooling, and excitation. Some of the pumps are, of course, spares.
3. Twelve 1508-hp. Stirling boilers.
4. Twelve underfeed stokers, with driving motors and forced-draft fans.
5. Boiler-feed pumps.
6. Two 2500-kv.-a. house turbines—noncondensing, with excitation.
7. Coal- and ash-handling machinery.

In general, the flow of thermal energy begins with the coal fired, which is its source. After conversion into steam, it drives all steam-driven apparatus, and finally is transformed into useful electric power. In this flow of energy there are numerous losses and two closed cycles of energy transfer. One of these closed cycles involves the energy returned to the boilers from the exhaust of all steam apparatus. This includes the condensate from the 60,000 kw. unit, the oil-cooling water and the exhaust from the house turbines and boiler-feed pumps. The other closed cycle is the power consumed by the boiler-feed pumps. This power is returned directly to the boilers in the form of pressure and kinetic energy. This cycle goes on continuously and, with the exception of slight frictional losses, there is no gain or loss, and hence the power delivered to the feed pumps has no effect on the heat balance.

The temperature of the hotwell water varies from 68 deg. to 100 deg. F., corresponding to the highest and lowest vacua, giving an average of about 80 deg. F. This is suitable for cooling the oil supplying the 60,000-kw. unit, and since a practically constant quantity of about 200,000 lb. per hour is required, which is heated to about 130 deg. F., a considerable heat saving is effected. A booster pump is necessary to raise the water pressure to get sufficient water through the oil coolers to produce the required cooling effect. This pump, however, consumes in power only about 1 per cent. of the amount of heat salvaged. Also, even if condensate were not used for oil cooling, an equal amount of water would have to be pumped by some other means.

AUXILIARIES MOSTLY ELECTRICALLY DRIVEN

With the exception of the boiler-feed pumps, which, owing to their inherent operating characteristics, do not lend themselves well to electrical drive, all auxiliary apparatus is electrically driven. Power for this purpose is supplied by two so-called house turbines. The function of these turbines is twofold: First, to supply power for auxiliaries, and second, to supply exhaust steam for feed-water heating purposes. The auxiliaries could have been driven by power taken from the main bus, and steam could have been bled from the 60,000-kw. unit for the feed water; but the advantages accruing from the independence of power source and the avoidance of a possible shut-down because of motor trouble due to a jolt coming in from the main line made the house turbines advisable. The advantages of these turbines over individual turbine drive, are: First, they eliminate entirely the waste of surplus exhaust, for they may be set to furnish exactly the amount of exhaust steam required for feed-water heating under all operating conditions by adjusting their kilowatt output in accordance with the feed-water heating demands as indicated on the corresponding curves. It should be emphasized here that the controlling factor for house turbine operation is feed-water heating requirements and not auxiliary power requirements. Second, the house turbines afford the convenience of individual motor drives and eliminate a large amount of steam piping, and third, turbine speed reduction gears are entirely done away with, the reduction being accomplished electrically.

The house turbines are electrically connected through transformers with the 60,000-kw. unit in parallel and float on the line. They are set to furnish the required amount of exhaust steam necessary for feed-water heating purposes for any particular station load. If this loading exceeds the power demanded by the auxiliaries, which condition occurs at heavy loads, the excess is available for and may be credited to the station load. If the opposite condition prevails, as it does at light loads, the deficit is supplied by the main unit, and this power must accordingly be deducted from the station load. It is much more economical to take this power from the main unit than it is to load the house turbines to the necessary capacity and waste the surplus exhaust. The ratio of steam consumption for the production of equal amounts of power by the house turbines and the 60-000-kw. unit is approximately 25 to 11. Taking into consideration the thermal energy returned in the condensate from the main unit, it is thus about 2.4 times more expensive thermally to generate power by means of the house turbines when surplus exhaust must be sacrificed. However, on the other hand, up to the point of surplus exhaust, it is about three times more expensive to produce power for any purpose with the main unit. This is due to the fact that up to this point power is produced by the house turbines for practically nothing. Since all of the exhaust heat, including all latent heat, is returned to the system, the only losses are from radiation and friction.

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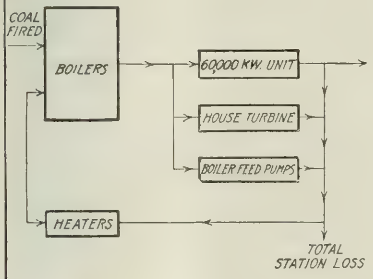
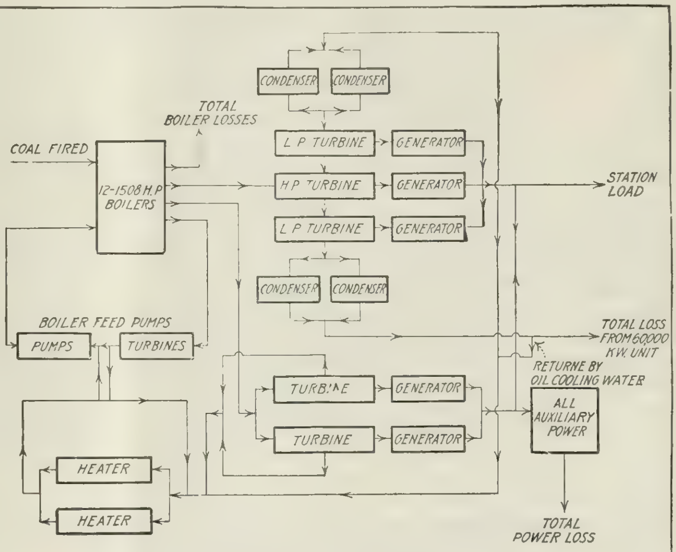
* Chief, Mechanical Division, J. G. White Engineering Corporation.

†Mechanical Division, J. G. White Engineering Corporation.

From the foregoing it is evident that thermal efficiencies will be increased by raising the "surplus exhaust" point and obtaining all the power possible from the house turbines. This may be accomplished by increasing the back pressure, which will increase the amount of exhaust required for feed-water heating purposes, and, therefore, raise the "surplus exhaust" point. A limit to this procedure, however, is imposed by the fact that the steam consumption of the house turbines is not constant, but increases more and more rapidly with the back pressure, and also, in smaller measure, by the fact that the heat content of the exhaust becomes greater. A point is thus reached where the power obtainable from the house turbines, without surplus exhaust, begins to decrease as the back pressure is increased, even though more exhaust steam is called for. This point will, of course, vary somewhat with the station load, but is in all cases considerably in excess of 5 lb. The saving between 2½ lb. and 5 lb. back pressure amounts to about 1 per cent. at a station load of 50,000 kw. The percentage saving increases at light loads. Because of the fact that the turbine casings and the feed-water heaters are not designed to safely withstand a greater operating back pressure than 5 lb. and also because starting becomes more and more difficult with high back pressures, 5 lb. represents about the maximum.



STATION ENERGY FLOW IN GENERAL
FIG. 1



STATION ENERGY FLOW IN DETAIL
FIG. 2

Fig. 1 illustrates the flow of energy involved in the generation of power, as a whole. As will be seen, there is a closed cycle, a certain amount of energy being taken from and returned to the boilers. The two extractions from the system are the available station load and the total station losses, the sum of which must equal the coal fired.

Fig. 2 illustrates the foregoing in detail. Losses from radiation and friction have not been included.

The expression for determining the quantity of exhaust, and hence the loading of the house turbines, for feed-water heating under various conditions is developed as follows:

A back pressure of 2½ lb. has been assumed.

An average steam consumption of 25.7 lb. per b.hp.-hour has been used for the boiler-feed pumps.

The average makeup-water temperature has been assumed to be 70 deg. F.

If $c =$ Condensate from 60,000 kw. unit $=$ lb. per hour.
$o =$ Condensate from 60,000 kw. going through oil cooler,
$n =$ Condensate from 60,000 kw. not going through oil cooler,
$h =$ Exhaust from house turbines — lb. per hour.
$f =$ Exhaust from boiler-feed pumps,

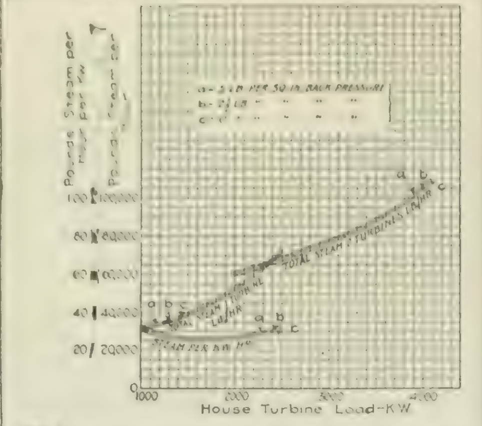


FIG 3

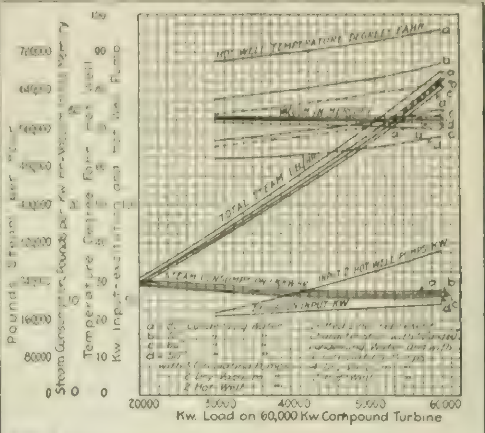


FIG. 4

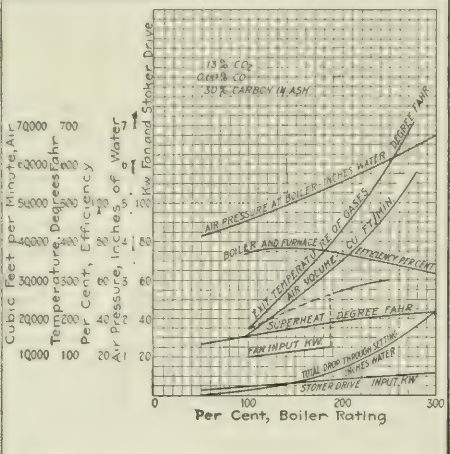


FIG. 5

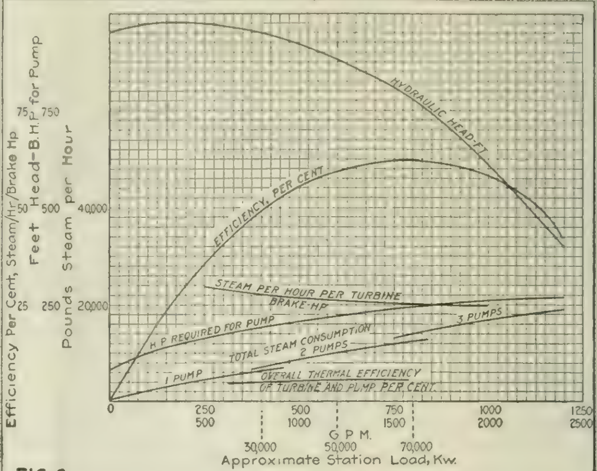


FIG.6

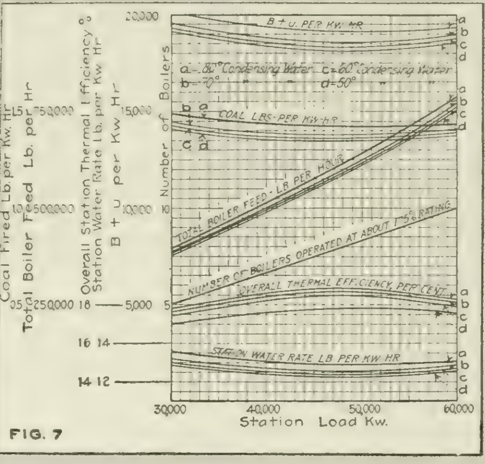


FIG. 7

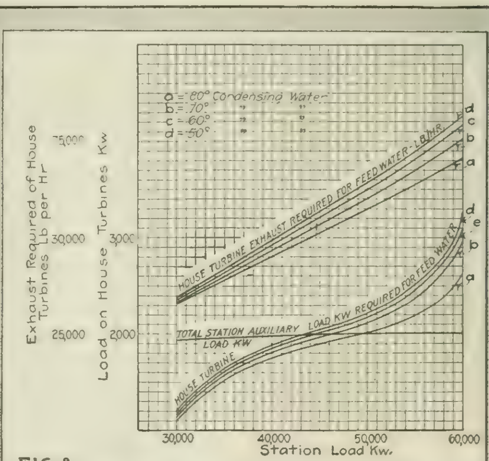


FIG. 8

FIGS. 3 TO 8. GRAPHIC HEAT-BALANCE STUDIES OF U. S. NITRATE PLANT NO. 2

Fig. 3—Showing performance of house turbines under variable loading. Fig. 4—Performance data for the 60,000-kw. unit under different temperatures of circulating water. Fig. 5—Boiler and furnace characteristics. Fig. 6—Operating characteristics of boiler-feed pumps. Figs. 7 and 8—General station-operating characteristics and economies.

m = Makeup-water = 3 per cent. of above,
s = Total boiler feed = $(c + h + f + m)$,
T_h = Temperature of cold well, and
H_c = Total heat in condensate at heaters at $(T_h - 5)$,
then

$$(o \times 100 + n \times H_c) + (h + f) \times 1153.1 + m \times 38 = 187.5 \times s$$

The boiler-feed pressure is about 325 lb., which is equivalent to 760 ft. of water; 60 per cent. is used for the pump efficiency. Then

$$f = \frac{760 \times 25.7}{500 \times 3960 \times 0.6} \times s = 0.0172(c + h)$$

substituting and solving

$$h = 0.179c - 20{,}300 - \frac{Hc(c - 200{,}000)}{984}$$

for 2½ lb. back pressure

Similarly

$$h = 0.187c - 20{,}500 - \frac{Hc(c - 200{,}000)}{977}$$

for 5 lb. back pressure

Solving for s,

$$s = 1.05(c + h)$$

The number of boilers is determined as follows:

Steam is taken at 285 lb. gage with 180 deg. F. superheat.

If H_s = Total heat in live steam,
H_f = Total heat in feed,
N = Number boilers operated at 175 per cent rating,

$$N = \frac{s(H_s - H_f)}{1.75 \times 33{,}479 \times 1508} = \frac{s}{78{,}500}$$

The number of boilers is determined by the foregoing and then the exact rating from

$$\textit{Per cent. rating} = 0.00224 \frac{s}{N}$$

The boilers will normally be operated at or in the neighborhood of 175 per cent. Throughout this range, as may be gathered from the characteristic curves of the boilers, the over-all boiler efficiency remains practically constant at 76 per cent. and the superheat at 180 deg. F. With coal averaging 13,500 B.t.u. per lb., which will for the present represent the average obtained, the coal fired per hour, in pounds, will be

$$\frac{s(H_s - H_f)}{13{,}500 \times 0.76} = 0.11 \times s$$

The total station auxiliary load which has been included in the heat balance is:

Constant part independent of station load: 3 circulating water pumps, 2 dry vacuum pumps, 3 blower fans for generators, oil-cooler pump.

Variable part dependent on station load: Stokers, forced-draft fans, 2 hotwell pumps, excitation for 60,000 kw. unit, excitation for house turbines, coal- and ash-handling machinery.

This auxiliary load consumes power and must be charged against the production of the ultimate product, which is the available station load at the switchboard. It thus affects the amount of coal fired and the quantities expressing station economies.

The curves of Fig. 3 represent the performance of the house turbines under variable loading. From these curves it is possible to obtain the necessary loading for any required amount of house-turbine exhaust. These values are plotted in Fig. 8. The most economical range of operation with 5 lb. back pressure is between 1600 and 1800 kw., with a steam consumption of about 26.5 lb. per kilowatt-hour.

Fig. 4 gives performance data for the 60,000-kw. unit under different temperatures of circulating water. The steam consumption, in pounds per kilowatt-hour is based on the actual amount of steam passing through the unit and the actual generated station load and does not include the steam consumed in the production of auxiliary power, which is taken care of by the total station water rate in Fig. 7. The lowest steam consumption is about 10.4 lb. per kw.-hr. and occurs at a load of about 500,000 kw., using 50-deg. injection water. The corresponding figure with 70-deg. injection, which represents average prevailing conditions, is about 10.8 lb. per kw.-hr. These are exceptionally low figures. The explanation is found in the economies due to the size and design of the 60,000-kw. unit and in the high heat content of the steam. Large units favor economy.

Fig. 5 shows the boiler and furnace characteristics. Two constant-speed squirrel-cage motors are employed for the forced-draft fan drive. The smaller one is entirely adequate for all ordinary loads, and the larger one is only used for occasional high overloads. The highest guaranteed boiler and furnace efficiency is about 77 per cent. occurring at about 140 per cent. It is hoped, however, that by virtue of the large combustion chamber and the fact that the entire boiler setting has been carefully and thoroughly insulated with a heat-insulating brick, and by close attention to operation, that the boiler efficiency may be bettered by possibly as much as 5 per cent.

Fig. 6 shows the operating characteristics of the boiler-feed pumps. The steam consumption is given for variable station load, making possible the determination of the amount of exhaust furnished by the feed pumps at any station load.

Figs. 7 and 8 illustrate the general station-operating characteristics and economies. The coal fired per kilowatt-hour attains a minimum of 1.35 lb. at a load of about 45,000 kw. with 50-deg. injection water. This is based on 13,500 B.t.u. coal; 14,000 B.t.u. coal would bring this figure down to 1.3. The corresponding minimum heat consumption is 18,200 B.t.u. per kw.-hr. The over-all station thermal efficiency reaches a maximum of 18.8 per cent. at about 50,000 kw., with 50-deg. F. injection water. It will be appreciated that these figures represent exceptionally high economies. Radiation losses have not been included in the computations, but these will be minimized by the heat insulation applied to all sources of such radiation. Blowdown losses and losses arising from careless handling (for example, coal), also have not been considered. But conservative figures have been used throughout, and it is expected that their betterment will at least offset the losses mentioned and that even higher economies will be obtained.

The total station auxiliary load is nearly constant between 30,000 and 60,000 kw.; the reason being that the major portion of this load is constant. The house-turbine load required for feed-water heating equals the station auxiliary load at about 45,000 kw. Below this point the deficit in auxiliary power must be made up by the main unit; above, the excess over auxiliary power is utilized for station load. The explanation of the discontinuity in the curves representing house-turbine loading lies in the fact that the first portion is for one machine, and the following portion for two machines. As will be noted, the point of inflection, or change, occurs at 2000 kw., which is the point at which a second machine must be started.

How To Build Low-Voltage Direct-Current Electromagnets and Solenoids

By HENRY W. TOWNSEND

Data on the construction of direct-current traction as well as solenoid types of magnets, for use on battery circuits, which have actually been built and tested.

THE design and construction of electromagnets for a given duty is not one of the easiest jobs, and this is so for many reasons. For one thing the grade of iron or steel used for the cores may vary, and unless an actual test is made of magnetic material's permeabality the finished magnet is quite likely to be off 10 or 15 per cent. from the calculated performance. Again, the coil or coils may not be constructed exactly to specifications and of course this introduces another error. Therefore, the appended data on a series of electromagnets, including solenoids, which have been built and tested, should be of service to electrical and mechanical men who frequently have a use for such apparatus.

A few instructions will be given in the discussion regarding the practical building and application of electromagnets, but the theory will be left out, as there are available plenty of textbooks dealing with the mathematics of electromagnet design.

The design shown in Fig. 1 is a double-pole electromagnet used on a polarized relay. It will prove very useful where one needs a relay for telephone and signal circuit. The principal dimensions are given in the figure. In all the magnets shown commercial wrought-iron bar, procurable at any machinery-supply shop, has been found very satisfactory. For small magnets the rough outer coating of the iron may be turned off in a lathe, if desired, to make a better-finished and more accurate job.

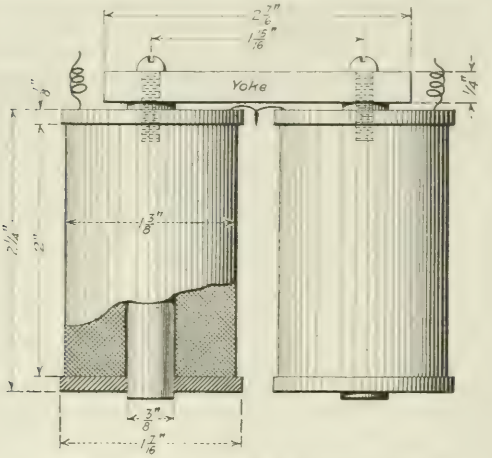


FIG. 1. DOUBLE-POLE ELECTROMAGNET

Pay particular attention in every case to the "fit" made between cores and yoke. The abutting faces should be machined or filed very accurately, as the magnetic flux must pass through these joints without leakage or else the magnet will have a low efficiency; this is particularly true in the larger-sized magnets. Be careful to face off the pole faces square, particularly where an armature is used, as in Fig. 2. The armature should be of the same stock as the cores and yoke and of the same cross-section. That is, if the round core has one square inch area of cross-section, then the yoke and armature should have this cross-secticn also. In a small relay this is not always done, as the armature, to have the requisite delicacy of balance, may be smaller in cross-section than the cores, consequently the flux density through this part will be higher.

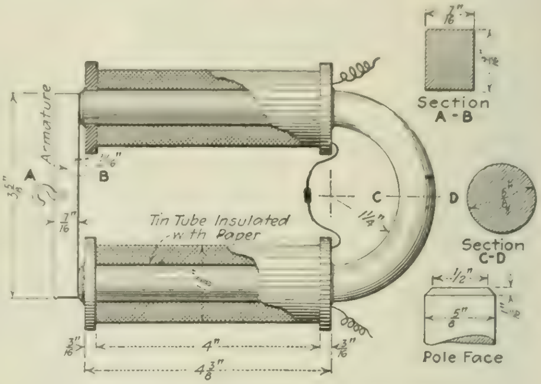


FIG. 2. HORSESHOE ELECTROMAGNET

The bipolar (two pole) electromagnet of Fig. 1 may have fiber or hard-rubber ends on the coil spools. The core between the disks should be carefully covered with two layers of thin fiber or white note paper and may then be shellacked. Do not make the mistake of using a single fine wire lead from the coil; use a stranded lead (lamp cord is often used) or make one up of several pieces of No. 32 or 34 B. & S. bare or insulated wire and solder it to the fine wire comprising the magnet winding. Take two or three turns around the core with this flexible reinforced lead, and it will never pull out. A good method of forming both inside and outside terminals on small magnets is to use brass nails driven through holes in the fiber ends of the spool just small enough to make a driving fit; machine screws are also often used. In any event file them flat with the inside of the fiber face and solder the leads to them, and then place a small piece of silk or linen tape on the soldered joint.

To connect the coils in series the two inside or outside leads are joined together and the other two leads brought out for terminals. In a parallel connection the inside terminals of the coils are connected to the outside terminal and connection brought out from the junction point. Relay electromagnets are invariably connected up series, as the current in amperes required to actuate them is generally very small.

The coils for the design, Fig. 1, are wound in even layers, either in a hand winder or in a lathe, with one of the following sizes of magnet wire, depending upon the resistance required. No. 40 B. & S. single-silk covered (s. s. c.), total resistance of two coils in series equals 15,000 ohms; No. 39 B. & S., s. s. c., total resistance equals 10,000 ohms; No. 38 B. & S., s. s. c., total resistance equals 5000 ohms; No. 37 B. & S., s. s. c., total resistance equals 3750 ohms; No. 34 B. & S. s. s. c., total resistance equals 937 ohms. One-half the foregoing values of resistance may be obtained by connecting the coils in parallel; the latter will be found most useful on signal circuits operated from battery voltages.

Be careful in connecting up the two coils, in series or parallel, to get the polarity correct. One pole must be a north and the other a south, in every case for all electromagnets of this typ

DESIGNING A BATTERY LIFTING ELECTROMAGNET

Fig. 2 shows the design of a battery lifting electromagnet. The core is made of one piece of soft-wrought iron—mild cold-rolled steel is often used as a substitute—bent in U-shape as indicated. The magnet bobbins are formed by placing fiber disks on sheet-tin tubes, permitting them to be wound on a wooden or other mandrel in the lathe. The tin tubes are soldered along the joints after the fiber end washers are in place. The ends of the tube are allowed to extend about one-eighth inch beyond the disks and slit, bent up and solder run around the upturned tabs, forming a substantial spool. Cover the tubes with two layers of thin fiber or paper, shellac them and wind on each spool 14 even layers of No. 22 B. & S. single cotton-covered magnet wire. Connect the coils in series to give resultant N and S poles, by compass test or by observing which way the windings run, as explained for Fig. 1. If the coils "buck" each other, the magnet will be very weak, hardly attracting a nail.

This little battery magnet is very handy for a wide variety of purposes, as, for instance, in picking up screws and nails from stock bins and barrels. It will pick up several pounds of nails and screws at one time, and the windings can easily be changed to finer wire for use on 110-volt direct current.

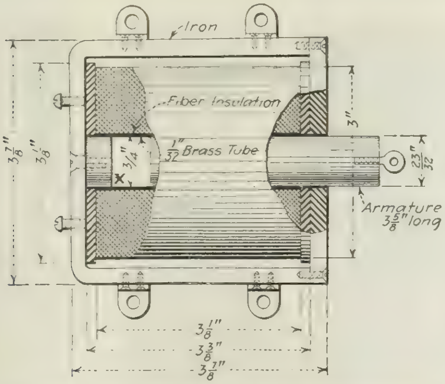


FIG. 3. SOLENOID-TYPE ELECTROMAGNET

On test this electromagnet, excited on 10 dry cells or 15 volts, took a current of 0.95 ampere and lifted 50 lb. The lifting power varies of course with the number of batteries used. For battery operation a storage battery gives the best result.

The design shown in Fig. 3 is for a solenoid type of electromagnet. In some experimental work it was found that the effective strength at different strokes could be about doubled by building a yoke of wrought iron or mild cold-rolled steel about it, so as to return the magnetic flux efficiently, instead of causing the flux to return from the N pole to the S pole through the air. The iron core carries the magnetism several hundred times better than air, as any iron permeability table shows.

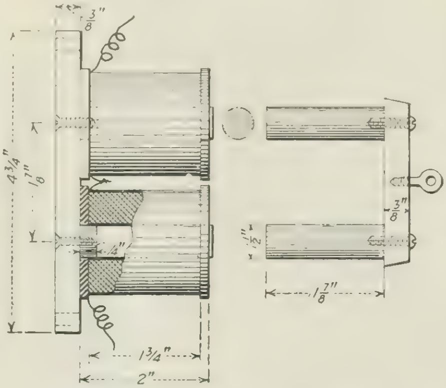


FIG. 4 DOUBLE-POLE SOLENOID

This solenoid is wound for excitation on 6 to 10 volts and was used with a storage battery in some experimental work. The spool and core dimensions are given in the figure. The bobbin is insulated with two layers of fiber or paper and then wound with 16 layers of No. 14 B. &. S. enameled magnet wire. The current consumed on 6 volts was 6.67 amperes, the ampere-turns (product of ampere and turns) was 5000 and the coil's resistance equaled 0.9 ohm.; weight of magnet wire, $3\frac{3}{4}$ lb. The pull in pounds at various strokes, distance between end of core and the end x, when excited on 6 volts storage-battery current, was as follows: Stroke 1 in., pounds pull 10; stroke $1\frac{7}{8}$ in., pounds pull 8.5

The pull of a solenoid is easily measured by a spring balance. Another good method is to attach to the core a pail which can be filled with sand. Sand is put in or removed, at each test on the core, until the solenoid can just pull it up. The pull is sometimes measured by means of a lever resting on a platform scale.

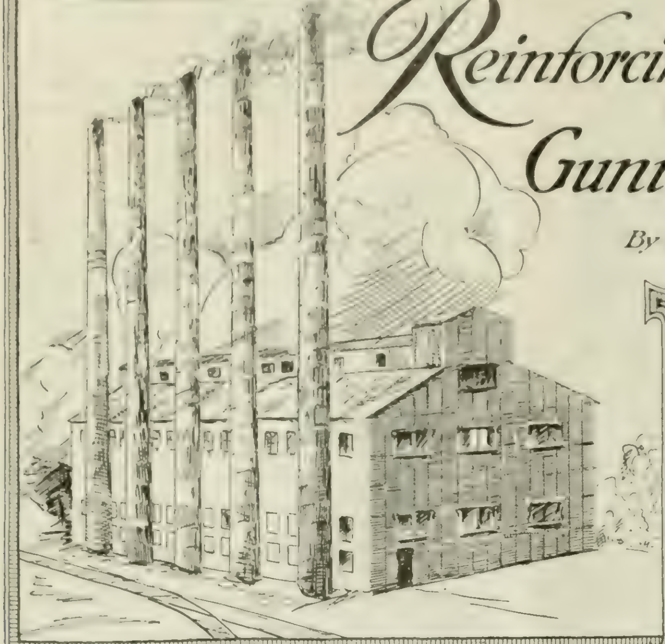
DOUBLE-POLE BATTERY SOLENOID

In Fig. 4 is given the structural dimensions of a double-pole battery solenoid. Each coil is wound with twelve even layers of No. 18 B. & S. single cotton-covered magnet wire. The two coils are connected up in series to give north and south poles. All the iron parts are of annealed wrought-iron stock. The bobbin shells, which are made up on a brass tube, are tightly fitted, soldered or riveted if necessary, to the stop cores. The resistance of each coil measures 1.25 ohms and the current taken at 10 volts is 4 amperes. The pull obtained at various strokes, is: At 1 in., 1.25 lb.; at 1.5 in., 1.1 lb. At 12 volts and 4.8 amperes the solenoid gave a pull of 2 lb. at 1-in. stroke. The stroke of a solenoid is the distance the armature moves through in lifting its load.

A future article will deal with the construction of electromagnets and solenoids to operate on 110- and 220-volt circuits.

Reinforcing Steel Stacks with Gunite Concrete

By M. C. Sherman



Seven self-supporting steel smokestacks, each 125 feet high and six feet in diameter, became so badly corroded that it was necessary to rebuild them. This was accomplished by placing steel bands, vertical rods and wire mesh around the stacks. Then gunite was applied to the steel and wire-mesh work, making when completed, practically a reinforced-concrete stack.

AN INTERESTING job of chimney construction was completed recently by the Baker-Dunbar-Allen Co., of Cleveland, Ohio, on five pit-furnace stacks at the plant of the Pittsburgh Crucible Steel Co., Midland, Penn.

The original stacks, which were of self-supporting steel, 125 ft. high and approximately 6 ft. in diameter at the top, were badly corroded, owing to the gas from the furnace finding its way through the brick lining of the stacks and eating out the steel plate. The corrosion became so general that it was necessary to rebuild or repair the stacks. It was important, however, that they be kept in service.

The work was carried out by building reinforcing self-supporting shells around the stacks, and then employing the cement gun. Accordingly, all details were

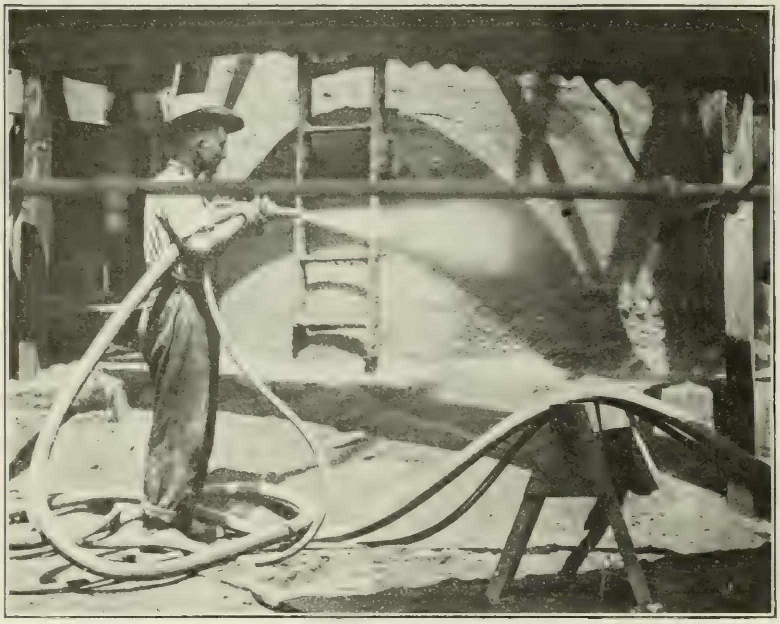


FIG. 1. APPLYING GUNITE MATERIAL TO THE BOTTOM OF A STACK

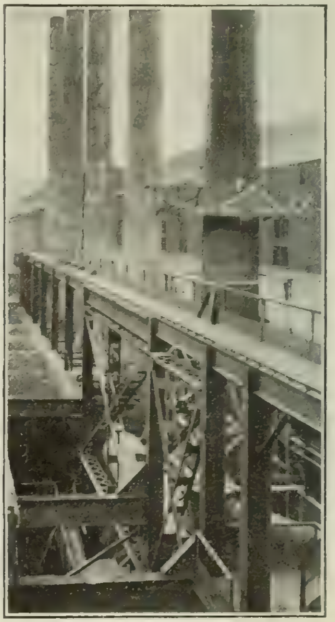


FIG. 2. FOUR STACKS COMPLETED

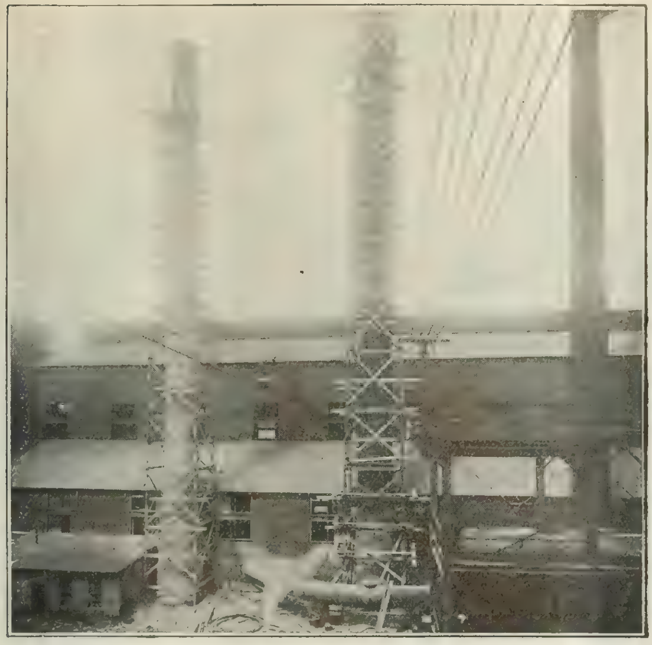


FIG. 3. ONE STACK COMPLETED AND SCAFFOLDING BEING REMOVED

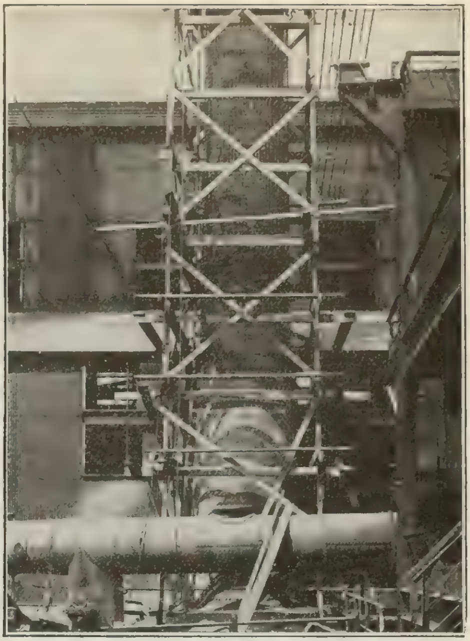


FIG. 4. CLOSE-UP VIEW OF ONE OF THE STACKS

worked out and the reinforcing cement envelope was applied. The new stacks have been in operation for over six months, and the construction has proved entirely satisfactory.

At each ring, bolts were tapped into the stack, these bolts carrying steel bands properly spaced, the bands in turn carrying vertical reinforcing rods of square twisted steel, around which was wrapped wire mesh. The gunite shells were applied against this reinforcement.

Each stack required approximately 1100 cu.ft. of finished gunite, which is reinforced with about 1½ per cent. of steel. After the completion of stack No. 2 it was thought that better results would be obtained by the use of swinging scaffolds of special design, instead of the continuous timber scaffolds. Accordingly the swinging scaffold was used on the last three stacks, with improved success over the timber scaffold that was first used.

Fig. 1 shows the nozzleman applying the material at the base of the stack. Fig. 3 shows stack No. 1 completed with the timber scaffolding in process of dismantling and stack No. 2 with the steelwork completed and the gunite at the base applied. Fig. 4 is a close-up view of stack No. 3, showing the nicety of steel-reinforcement work and applied gunite material. Fig. 2 shows four stacks completed and the fifth stack partly completed. Fig. 2 shows the swinging scaffold and Figs. 3 and 4 the timber scaffolds.

The finished work presented a somewhat splotched appearance, as shown in Fig. 2. This, however, disappeared as the gunite dried out. Special precautions were taken to keep the gunite moist until a full setting was obtained.

A great advantage in this method of building these stacks lies in the fact that they were kept in nearly constant operation during the progress of the work. Four of them were shut down for a few days while the gunite was being applied to the upper portions. One stack, however, was kept in constant operation while the work was being done.

The method of construction was less expensive than building forms around the present steel stacks and applying ordinary concrete. The speed of the work was also much greater; the operating force often applied 25 to 30 ft. of gunite, instead of the 5 or 10 ft. possible with the use of commonly used forms and ordinary concrete.

Undoubtedly, this gunite method (patent applied for) could be applied to a great many stacks that are in a poor state of repair, and it should be of particular interest to steel-mill operators, or anybody who has a self-supporting stack in need of repair and operating under conditions that make it inconvenient to cut it out of service, as the gunite as shown in the foregoing can be applied while the stack is in use as well as when it is idle.

Stationary Boiler Superheater

With the adoption of the steam turbine in power-plant practice, the use of superheated steam has become so common that practically no turbine plant is operated with saturated steam. By the use of superheated steam the efficiency of the turbine is increased through the elimination of losses due to friction in the nozzles and blades and the windage loss. The use of turbines has also led to increased steam pressure on larger boilers, which has necessitated a like growth in the size of superheaters and details of design have also kept step with the general progress of the modern power plant.

One of the latest entries into the superheater field for stationary power plants is the Locomotive Superheater Co., Woolworth Building, New York City. This company has recently brought out a new type of superheater for use in stationary plants, and the following points have been kept in mind in working out the design: Safety; accessibility for inspection and repairs; protection against overheating; high superheating efficiency; improved efficiency of combined boiler and superheater; consideration of steam velocities and areas to provide minimum drop in steam pressure; uniformity of superheating and ease of regulation; provision for expansion and contraction; provision for cleaning; minimum possibilities for leaks; and flexibility and adaptation to many different designs of boilers manufactured

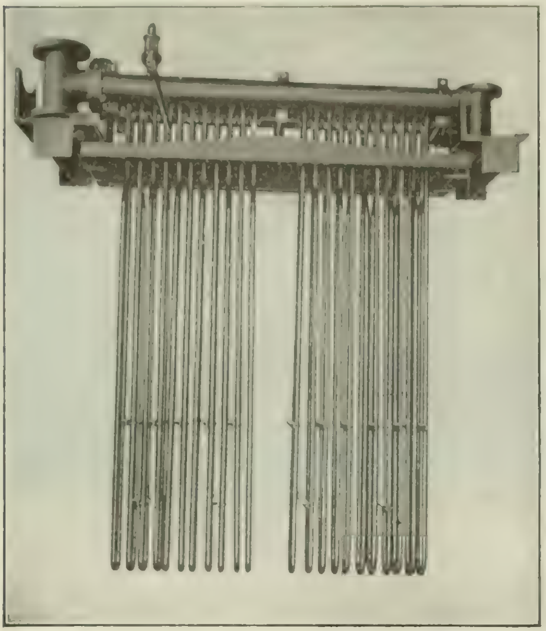


FIG. 1. SUPERHEATER HEADER ASSEMBLED

As shown in Fig. 1, the superheater consists in general of two headers, one acting as the distributor for the saturated steam coming from the boiler and the other as a superheated header for the collection of the steam after it has been superheated, and the necessary connecting units in which the actual superheating takes place. The headers are of steel and are located outside of the hot-gas path, usually outside the boiler setting proper. In most cases the headers are made with the outlets on the superheated header in an opposite location to the inlet on the saturated header, and where conditions require the saturated header is provided with several inlets.

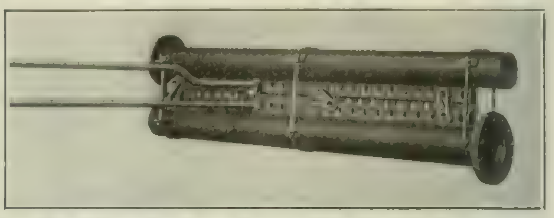


FIG. 2 HEADER SHOWING METHOD OF ATTACHING UNITS

The superheating units are of heavy cold-drawn seamless steel tubing, bent in such form as to provide freedom for expansion and contraction. They are connected to the headers by means of ball-and-socket joints with ground surfaces. The ball of the joint is forged on the end of the tube, and it is then faced and ground. It fits into a ground seat in the header, made at an angle of 45 deg. The ball and seat are held in close contact by means of clamps, bolts and washers. Fig. 2 shows a superheater header, showing methods of attaching the unit, and Fig. 3 shows the general construction of the superheater and illustrates several plans for installing it in vertical water-tube and return-tubular boilers.

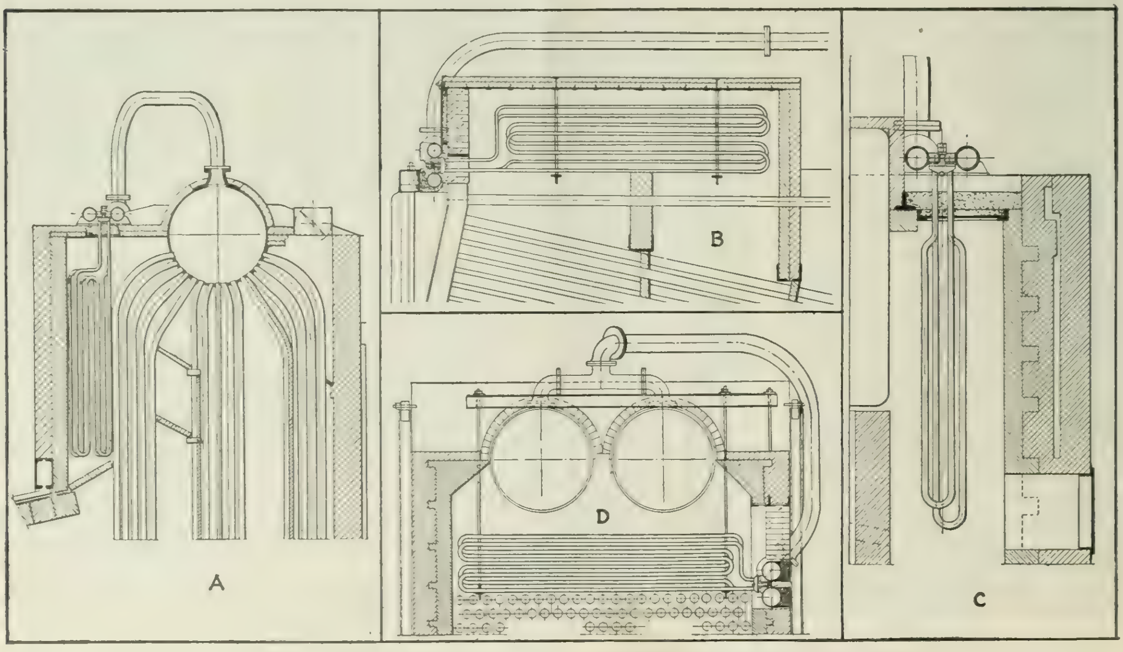


FIG. 3. SUPERHEATER AS APPLIED TO SEVERAL TYPES OF BOILERS

MECHANICAL EQUIPMENT *at* JOHNS HOPKINS UNIVERSITY

By Julian C. Smallwood

ORDINARILY, the mechanical equipment of a technical school falls in two distinct classes: First, that necessary for power, light and heat service; and second, that to be used for educational work only. It frequently happens, however, that educational results are improved by employing both of these classes; but as the service units are seldom arranged to suit the needs of laboratory students, much of the possible benefit is unrealized.

This is not the case with the engineering school of Johns Hopkins University. Naturally, the power plant is designed primarily with a view to providing economical and continuous service, which, of course, means the installation of modern engines and scientific instruments. But of nearly equal prominence is the purpose to include not only every usual facility for undergraduate experimentation, but also all practicable means for research, usual and special. In fact, it may be said that research is the keynote of the whole equipment.

SPRAY POND FOR COOLING CIRCULATING WATER

There are two power plants, the main one furnishing winter service through one of three steam units exhausting into the heating system, which may also receive reduced high-pressure steam. These three units consist of two turbine-generator sets and one four-valve reciprocating engine direct-connected to a generator. Any of these may be used for regular service or for student tests. There is an elaborate grid resistance installed in a separate room, with which an artificial load may be secured for the latter purpose.

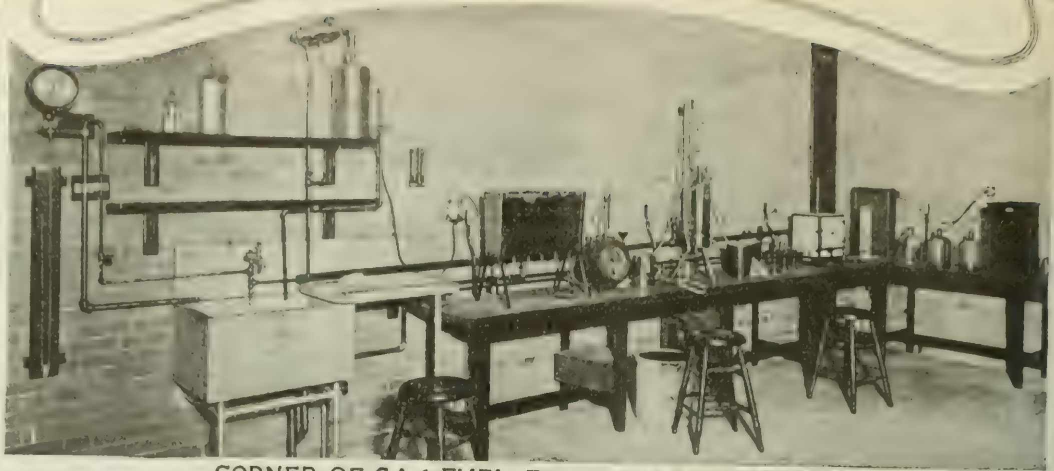
In the boiler room of the main power plant are four 250-hp. Babcock & Wilcox boilers, this large capacity being provided for future heating service. One pair is equipped with Roney and the other with Taylor stokers. Coal and ash are weighed when fired or removed, and the weights are recorded. The performance of the boiler room is at all times under observation through the autographic recording equipment, which includes a CO_2 recorder and a flue-gas thermometer not shown in the illustrations.

The vacuum heating system discharges its condensate into a receiver from which it is drawn by one of two feed pumps, and thence the feed passes through a closed feed-water heater and back to the boilers. Makeup water is provided automatically to the receiver. The boiler room almost runs itself, since the control is largely automatic as to both feed and draft.

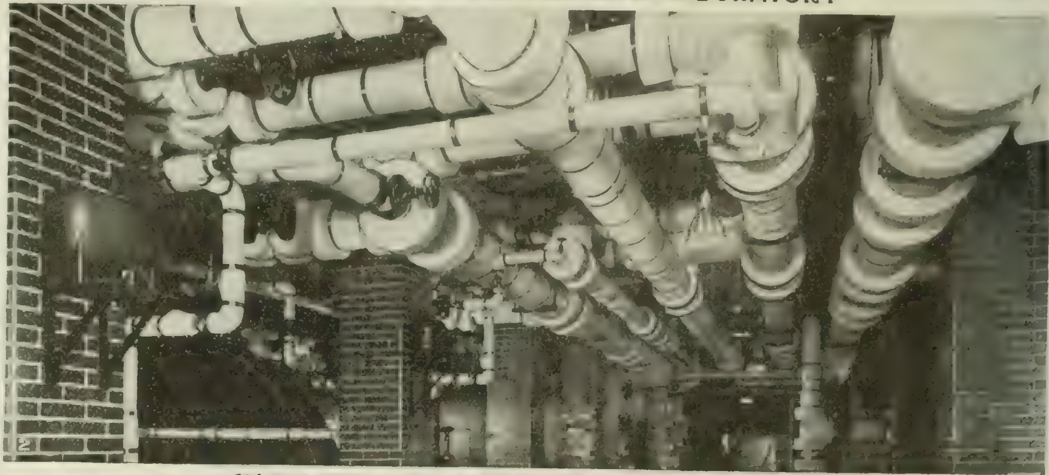
The second power plant referred to is a 50-kw. Locomobile of American design (Buckeyemobile). This is in regular service during the warm months only, when there is no heating load, as it operates condensing. A surface condenser is used and the circulating water is cooled in a spray pond. The whole comprises an exceedingly economical unit as is evidenced by results of student tests—which, of course, fall short of professional operation—amounting to 2.26 lb. of coal per kilowatt-hour at rated load.

Supplementing both plants is a storage battery intended for night and Sunday lighting service. The saving in labor charge at the power plant during the periods when the battery is delivering current makes an ample return on the investment, besides having the indirect effect of making a higher load factor for the steam-power plant.

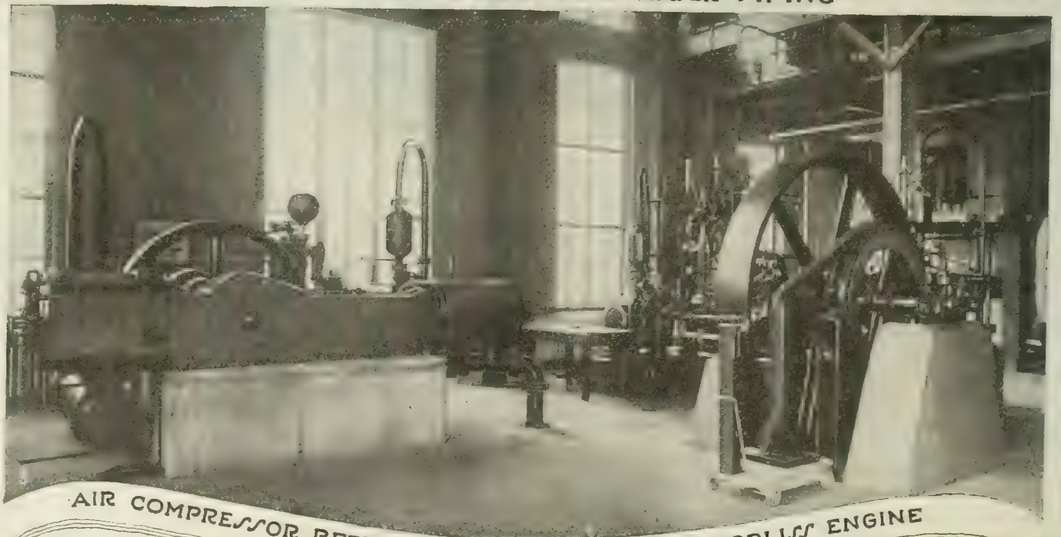
As regards testing equipment of all the service units, these are exceptionally complete in all the usual particulars, and in addition they have some very nice features of arrangement. For example, although the three main engine-room units, in regular operation, exhaust into the heating system, a surface condenser is provided into which any one of the three may exhaust for the purpose of steam-consumption trials. Two weighing tanks of 7000 lb. capacity are arranged to



CORNER OF GAS-FUEL TESTING LABORATORY

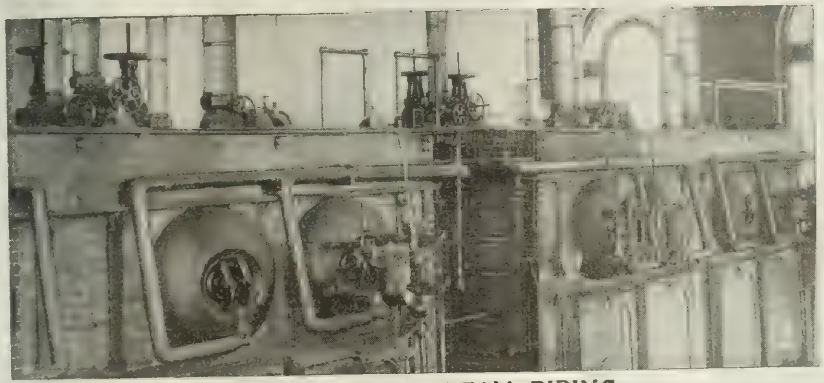


INSULATION OF STEAM AND WATER PIPING



AIR COMPRESSOR, REFRIGERATING MACHINE AND CORLISS ENGINE

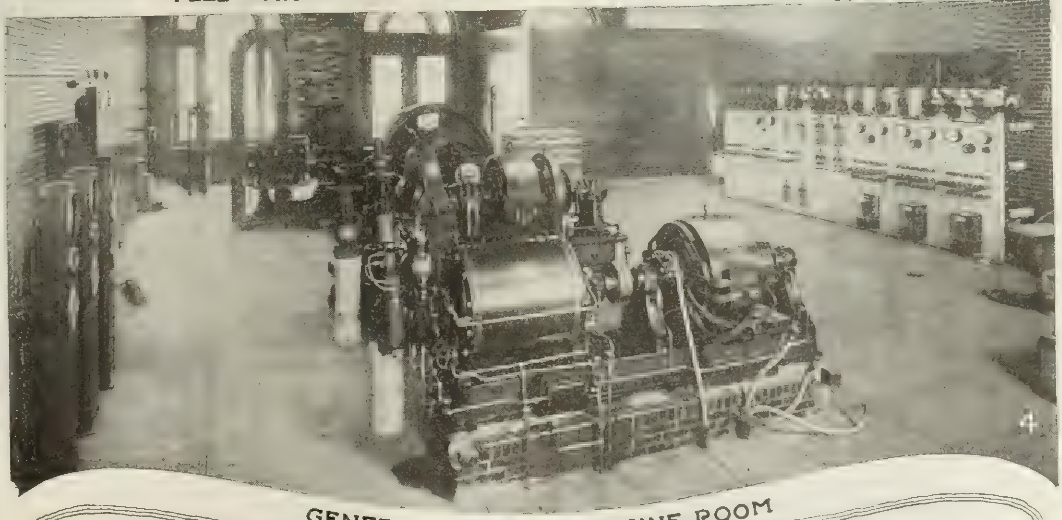
VIEW OVER TOPS OF BOILERS



FEED-WATER AND STEAM PIPING

3

MEASURING AND RECORDING INSTRUMENTS



4

GENERAL VIEW OF ENGINE ROOM

measure condensate, feed water to boilers or circulating water to spray pond. The last named is also supplied with a weir and V-notch recorder, recording thermometers, hygrometers, etc., by which very complete spray-nozzle tests may be made.

The boiler room contains some unusual facilities for research. The air supply to the Taylor stokers passes through a Thomas electric air meter, thereby enabling the measurement of the total amount of air during a boiler test. The settings of all boilers have numerous capped openings for the insertion of thermocouples, flue-gas sampling pipes or draft gages.

The stack is furnished with two iron balconies, or landings, as shown in the headpiece, one 50 ft. and the other 70 ft. above the grates. At each landing are eight capped openings for the insertion of draft tubes, thermocouples and pitot tubes. At the base of the stack, separated from the stack proper by a concrete floor just beneath the bottom level of the breeching, is an instrument room in which temperatures, drafts, etc., are read, these readings applying to various levels from the base up to the top. Some interesting experiments have been made with this equipment and will be continued.

The equipment provided strictly for experimental work includes the following: A 15-ton Frick refrigerating machine arranged to run dry or flooded, with calibrated tanks or weir measurement of brine and scales for ammonia weighing; an Ingersoll-Rand two-stage air compressor; several steam engines with the usual testing outfit; an 80-hp. Diesel engine with compensating prony brake; a Smith 25-hp. suction gas producer supplying a 14-hp. Nash gas engine; a Studebaker auto engine with fan brake; and various other small gas and gasoline engines. All of the more important internal-combustion engines are fully equipped for complete heat tests.

An unusually well-supplied laboratory is provided for fuel and gas testing, in addition to the instrument-calibration laboratory.

In a special building is a miniature illuminating-gas byproduct plant, erected and equipped for research.

Taken in its entirety, it may well be judged that here is an equipment fully calculated to maintain in mechanical engineering the traditions for which Johns Hopkins is known in other branches of science.

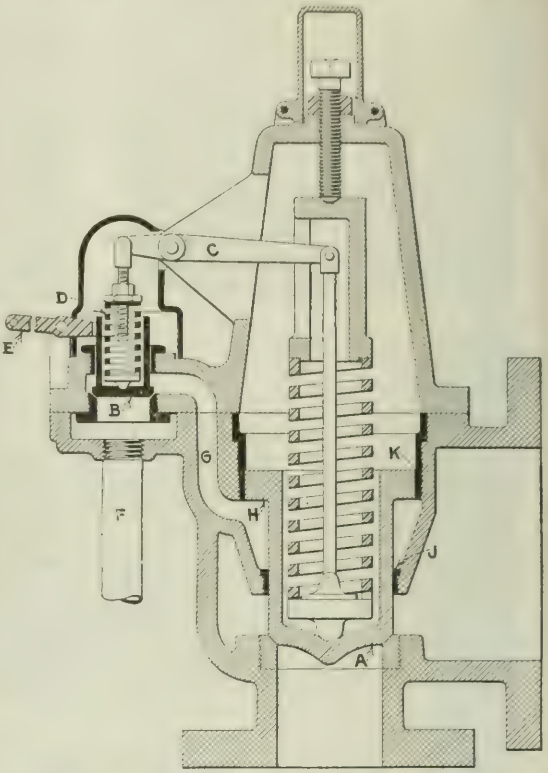
Full-Capacity Safety Valve

In the early days of steam boilers, when pressures were measured by atmospheres, and one or two atmospheres was considered a high pressure, and when the capacities of boilers were small compared with today's practice, a simple weighted valve, without lever or spring, was considered a good safety valve. With the increase in pressures and capacities came the weighted, or lever, type of safety valve.

A still further increase brought out the present spring-loaded valve, with which everybody having anything to do with steam is familiar. It would seem, however, that safety-valve capacity has not kept pace with boiler capacities, and the valve illustrated herewith has been designed as a solution of the problem. It is manufactured by Atwood & Morrill, Salem, Mass.

The valve is of the pilot-operated type, in which the main valve *A* is set at a somewhat higher pressure than the pilot valve *B*, and the movement of the main valve *A* has a direct cutting-off action on the pilot valve *B*. In other words, while this valve will open to full capacity where there is a continued increase of pressure, it will not do this at the first pop. This can be arranged so that it will extend over, say, a range of five pounds.

The cutting-off action of the lever *C* acts directly on the pilot valve spring *D* and consequently has a controlling effect on it. The lever *E* is for the purpose of testing, and the pipe *F* is the feeding pipe for the valve. This could be eliminated and a cored passage cast to a point below the main pop *A*, or it would undoubtedly have a steadying effect on the valve if this pipe were used and connected to a point in the steam drum at some distance away from where the safety valve is attached.



SECTION THROUGH PILOT AND MAIN VALVE

An upward movement of the pilot valve *B* allows a flow of steam through the passage *G*. This acts upward on the annular surface *H*, thereby opening the main valve. A movement of the main valve, as described, has a choking, or slowing down, effect on the pilot-valve spring *D*, and consequently on the pilot valve *B*. Continued increase of pressure at *B* means a greater opening of the pilot valve, and consequently a greater opening of the main valve *A* to the extent of a full opening, if required. The main valve *A* is loosely fitted to *J* and *K* to take care of steam which passes the pilot valve *B* after it is closed.

A static transformer of 60,000 kw. capacity has been made in Germany for stepping up from 6250 volts to 110,000 volts. An over-all efficiency of 99.07 per cent. is said to have been obtained.

Making Each Coil of Ammonia Condensers Do Its Share

By A. G. SOLOMON

An engineer of long experience in the operation of refrigerating plants tells how he manages to make each coil of ammonia condensers do its share in the all-important absorption of heat from the ammonia gas.

THE compressor is usually in good operating condition. Once a year it is given a careful overhauling, and the suction and discharge valves and the valve cages are ground in so that all joints are gas-tight. But within reason the working condition of the compressor is not as important as the condition and intelligent handling of the ammonia throughout its cycle.

The compressor has to take the heat-laden vapor from the evaporator and send it to the condenser. At a stated speed for a compressor of known dimensions a certain number of cubic feet of vapor will be compressed and delivered to the condenser in a given time. A not too badly leaking valve or a little groove in the compressor wall will lower this cubical displacement so little that it can hardly be detected on an indicator diagram. A slight increase in the clearance space will hardly be noticeable except by close and accurate figuring.

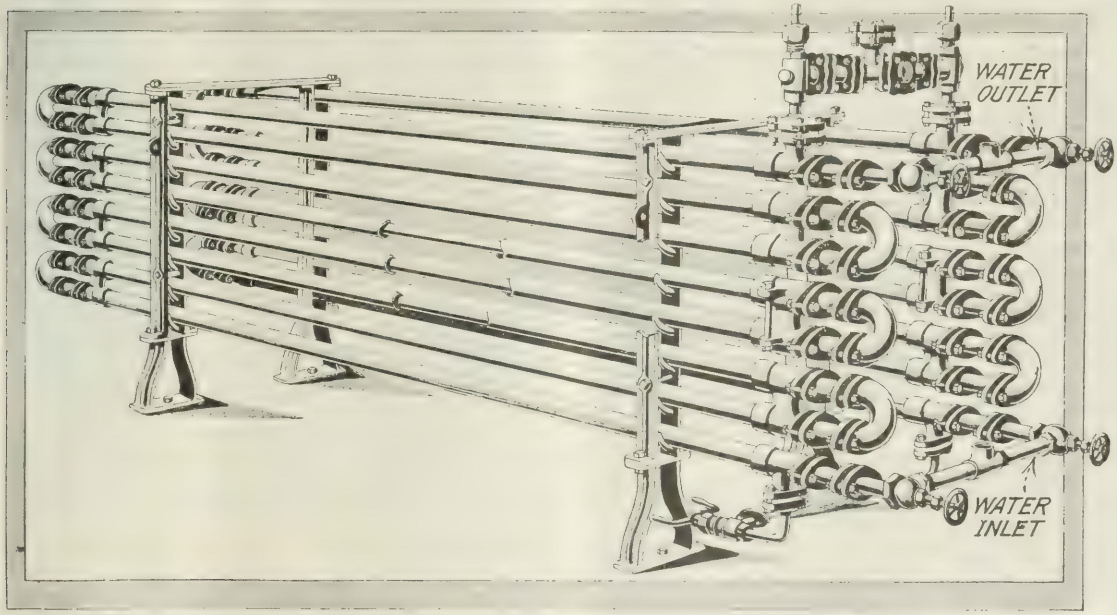


FIG. 1. SHOWING THE USUAL WATER-OUTLET CONNECTIONS

But the state of the vapor entering the compressor will make a difference that is readily apparent. So no matter how many cubic feet of vapor the compressor is able to displace, the objective which the engineer must strive for is to make every cubic foot carry as many heat units as possible from the evaporator and then to see to it that the greatest possible number of heat units are carried away by the circulating water at the condenser.

To make the whole refrigerating plant as efficient as possible, the amount of heat taken from the ammonia in the condenser is the main point to be kept in mind. Briefly stated, get all the heat possible out of the produce and into the ammonia, and then get this heat and the heat of compression out of the ammonia and into the circulating water. In the double-pipe ammonia condenser the water circulating through the inner tubes is the agent that performs this function.

Most engineers become concerned if the scale on the internal surfaces of the boilers gradually increases until the fuel consumption per ton of refrigeration shows an increase. But the same engineers do not always realize that they can gain in refrigerating duty by watching the condenser just a little more than has been their habit.

Let us see what is considered "a trip around the condensers" when the condenser happens to be of the single-pipe atmospheric type. The very first thing noticed is the way the water flows over the pipes of each stand. If one stand is not getting what is thought to be its share, the valve for that distributing trough or pipe is opened more. Or if the water is splashing considerably, owing to one stand getting too much, that valve will be closed a little.

If the water-regulating valves frequently become clogged this point is kept in mind and some one of the engine-room crew has a "trip around the condenser" as part of his regular routine. Scale forming on the pipes of the condenser is prevented to some extent by washing them down with water having a good pressure behind it. And the scale is often hammered or scraped off the coils.

Most condensers of the double-pipe type receive little or no attention unless something happens. Some one of the engine-room crew will walk around this neglected condenser maybe once a day, and if he does not hear, see or smell ammonia escaping, all is well and good. In case of a leak the necessary repairs are made. The water circulation is scarcely given a thought.

In nearly all plants it becomes a regular habit to have the high-pressure gage show a certain number of pounds pressure on the condenser. Whether this is the pressure that should be carried is never questioned. Just so long as the pressure does not go up to a point that is thought to be too high, nothing is done to see if the condenser is working properly and liquefying the gas at the lowest pressure possible. And very few engineers know if each and every stand of the double-pipe condenser in his care is doing its full share of duty.

As this article is dealing only with the removal of heat units from the ammonia in the condenser, it will be taken for granted that the full amount of heat has been sent there for removal. First to be considered is the water circulation.

The writer has never had the pleasure of seeing the original water connections leading from a double-pipe condenser arranged in such manner that intelligent regulation could be maintained. Fig. 1 shows the usual practice. One can see at a glance that it is an utter impossibility to judge if the distribution of the water is proper for each coil.

The way this condenser is handled is at best a case of guesswork as far as the operator is concerned. The valves at both inlet and outlet of the inner tubes of every stand are wide open. This is true whether the condenser consists of three or of thirty stands. The only time that any of these valves are found partly closed is when there is an attempt made to economize on water, and at such times it is common practice to set every inlet or outlet valve the same. This may be one turn or three turns open; but whichever it is, they all get the same opening.

Imagine an engineer or boiler-room man setting all the water-feed valves the same on a battery of a half a dozen boilers. It wouldn't do. Neither will the setting of the water valves of the double-pipe condenser do if real efficiency is the object sought. Each boiler of a battery will not evaporate an equal amount of water, and there is just as much difference in the quantity of ammonia condensed in the different stands of an ammonia condenser.

Under changing operating conditions of the compressor there will be noticeable changes of the action of the condenser. We all know that at times one or more coils of a condenser will store full of liquid and the operating charge of ammonia will be reduced until the liquid is started circulating through the dead coil. When a coil stores ammonia in this manner it is easily located, as the whole stand will become as cold as the water entering the inner tubes. But when a coil only partly stores liquid or becomes what one terms slow or sluggish, it can continue in that condition for a long time without being noticed. If some of the coils are sluggish and deliver only a small amount of liquid to the receiver, some of the other coils will not condense their share of gas and the liquid that goes to the receiver from them will be warmer by several degrees than it should be.

To overcome many of the troubles found in double-pipe condensers, close watch of the water circulation is necessary. The drawing, Fig. 2, shows the water connections as they should be if the operator is to conveniently keep the condenser working efficiently. The inlet connections are the same as those in Fig. 1, but the outlet connections are different. By this arrangement the flow of the water through each coil can be watched, and, what is of greater importance, the temperature of the outgoing water can be taken at each coil.

It will be found that with all the water valves wide open there will be a temperature difference of as much as ten degrees at times between the outlet water of each of many different coils.

Let us suppose that the condensing water enters the bottom of the coils at 72 deg. In ordinary practice a rise of 7 deg. is maintained between the inlet and outlet water when a coil is working satisfactorily. But all the coils will not show the same. For some reason some of them get more gas than others, and again some have a slower ammonia circulation. A coil that handles a large volume of gas will heat the water more than one that is not condensing so much.

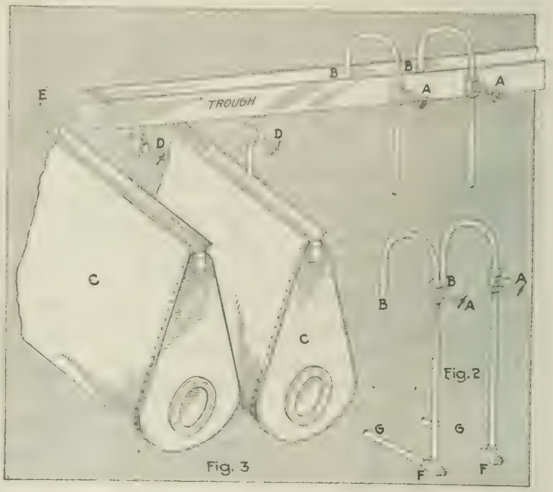


FIG. 2. SEPARATE WATER OUTLETS FOR EACH COIL

A, regulating valves; *B*, outlet where temperature is taken; *F*, tee with plug to facilitate cleaning; *G*, inner tube of top-pipe coil.

FIG. 3. TROUGH FOR WATER DISTRIBUTION OVER STEAM CONDENSERS

A and *B*, same as in Fig. 2; *C*, steam condensers; *D*, regulating valves (hand); *E*, overflow.

Now if one coil becomes very sluggish or slow in circulation, the water from its outlet will be but one or two degrees warmer than the inlet. This sluggish coil will cause a shortage of ammonia, and the circulation of gas through another coil will be rapid, therefore liquefaction is often not complete. The water leaving the inner tube of this hard-working coil will be heated as much as ten or fifteen degrees and even more.

With the separate water outlet from each coil and valves to regulate the flow, it is possible to have every coil of a double-pipe ammonia condenser doing an equal amount of work. It will take some time and patience before the regulation is satisfactory and the results noticeable; but when a real engineer is looking toward efficiency, he will be rewarded beyond his expectations.

At first temperature readings should be taken once every two hours; that is, the temperature of the outgoing water from each separate coil should be taken. If the water from one coil shows by its comparative coldness that too much water is being circulated for the work accomplished, the valve on that coil is closed a little. But do not expect to notice a difference during a few minutes or even a half-hour. Do not change the position of the valves oftener than once every two hours.

The best way to handle this temperature taking and water regulating is to have a card or suitable piece of paper tacked up close to the regulating valve of each coil. On this card mark down the temperature every two hours and also make a note as to what change is made in the position of the valve. In this way the valves will be handled intelligently and guesswork done away with.

After the proper flow of water through each coil has been found and the valves set, it will not be necessary to make further changes. The effect of this even temperature of the overflow water will be noticeable in the uniform liquid level in the liquid receiver. Also the regulation of the expansion valves will be easy as the temperature of the liquid will not vary.

In a distilled-water ice plant the separate outlet from each coil can be piped into a wooden or metal trough and the water for the steam condensers can be taken from this (see Fig. 3). The trough must be provided with an overflow so as to take care of any water that is not needed for the condensing of the steam. When a cooling tower is used, the outlets from the condenser coils are extended to the top of the tower.

Now that a method of water regulation is in use, the next step toward good results is free exchange of the heat from the ammonia to the water.

In another article the writer will deal with methods of cleaning the double-pipe ammonia condenser.

Rivesville, W. Va., New Power Plant

By J. W. Weir

Better electrical service for Fairmont and other towns served by the Monongahela Valley Traction Co. is being realized through the Rivesville, W. Va., power station, which is now in operation and is delivering energy to the lines and operating all of the car lines north of Jayenne, W. Va. In order to give better service the company has put the Rivesville station in operation before it is completed, and it will assist in carrying the load and at the same time add to its equipment until it has been completed and is ready to carry the load of the entire upper Monongahela Valley. At that time the Hutchinson plant, which has served the valley, will be kept in reserve so that in the development of the valley the traction company will be able to cope with the power situation.

The company's distributing lines from this station run as far north as Morgantown and as far east as Berryburg. A high-tension line is connected with the mines of the Maryland Coal Co., at Simpson and Galloway. They reach to Mannington and Baxter; a 66,000-volt line runs from the Rivesville station to the Hutchinson plant, and from that point power from the Rivesville plant is distributed over the lines that have been built into Hutchinson on to Worthington, Helens Run, Wyatt, Lumberport, through Clarksburg and on to Watson.

Some years ago the company built the Jayenne power plant. At that time it was thought that it would meet the demands for power for some time, but it was not long until it was outgrown. The Hutchinson power plant was then constructed and at the time this station was erected it was considered the best and most economical equipment that could be installed. The conditions at that time were right for the construction of that plant. Since its construction conditions have changed. What was then considered an inexhaustible gas field has been so depleted that the steam turbine plant is the more economical and especially so where the station may be supplied by coal mines within reasonable distance.

At the Rivesville station the main shaft of one of the company's mines is within sixty feet of the point where the coal is dumped into the hopper at the station to be carried by elevators to the stokers for the boilers. During the war period it was hard to get the needed repairs for the Hutchinson plant and in many instances the repairs that were secured were constructed out of inferior material. It was a case of the company doing the best that it could and all that it could to give its patrons the best possible service.

So the Rivesville station was built to take care of the rapidly increasing demand for electric power throughout, connections to it and to other mines in close proximity giving three sources for fuel.

The building is four stories high and is sufficient to house 50,000 kw., of which 20,000 is being installed. It is a fireproof steel frame and brick structure with steel window frames and gypsum roof.

The operating floor of the turbine room is 7 ft. above the 1885 flood and the boiler-room floor is 15 ft. above that mark.

An earth dike the top of which is 2 ft. above this highest flood mark will prevent water from running down the ash tracks into the boiler-room basement.

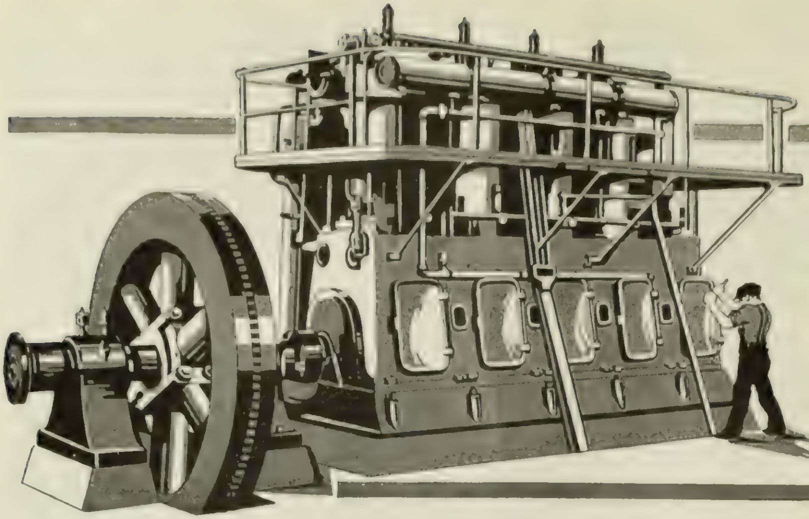
The boiler room is 115 x 150 ft., the turbine room 50 x 165 ft. and the switchhouse 27 x 165 ft. From the basement of the boiler house to the roof over the coal bunkers it is 108 ft. There is 20,000 cubic yards of concrete in the building, 1,500,000 bricks and 1500 tons of steel.

The boilers for the 20,000 kw. are four in number. Another will be completely installed within the next few days. They have a rated horsepower of 1245 each, and are of the horizontal cross-drum type. They operate at 250 lb. pressure and 250 deg. of superheat. They are fired by two underfeed mechanical stokers, one under each end of the boilers.

The coal is delivered from the mines on the property or from railroad cars into hoppers under the railroad tracks just outside of the building; from these hoppers it passes through crushers and by means of elevators and belts to the coal bunkers above the boilers. It feeds by gravity to traveling larries, which automatically weigh the coal and deliver it to the stokers.

Ashes are dumped into railroad cars which run underneath the boilers and are hauled away on the railroad or by trolley. All water used in these boilers is treated.

In the turbine room two 10,000-kw. turbo-generators are installed, with space for a 20,000- or a 30,000kw. machine. These units generate energy at 11,000 volts, which is stepped up at the outdoor substation to 22,000 and 66,000 volts for transmission to the various load centers.



Talks on DIESEL Engines

by L. H. Morrison

XVIII—*Turning from details of construction and operating troubles, the men discuss the status of the Diesel engine and the outlook for engineers trained to run this type of engine.*

THINGS had broken well all week, and so the crowd arrived at the meeting in a cheerful humor. "These are like old times," said Kelly, as he came in. "It used to be that we ran for weeks without a single breakdown and with the same old gang, too."

"Well," said Egan, "if conditions were the same we could do it again. In those days we had a 400-kw. load for an 800-kw. plant. We never ran at full load, for although we could have loaded one engine, our orders were to put on another unit when the running engine had more than three-quarters load."

"Why was that, J. R.?" Woods asked.

"In those days the oil engine was still regarded, at least in America, as a questionable source of power; so, to be safe, no one ever thought of having it pull full load. The operators were green and didn't know how to keep her up to the top notch. Really, a fellow was considered a born genius if he could keep her going twenty-four hours. At present I consider an engineer a poor one if he can't get practically full load for days at a time.

"In Europe, especially in Germany and Sweden, there are hundreds of plants, dependent on Diesel engines, that supply power to street railways, industrial factories and lighting systems. As much faith is put in them as we place in a steam plant. It is by no means uncommon in Germany to see plants containing 12,000 hp. in Diesels. In fact, units have been built of 6000 hp. each."

"I had the idea that we were as smart as the Huns," Kelly observed. "Probably smarter," retorted Egan. "In fact, smart enough to use whatever fuel nature supplied cheapest. So we stuck to our steam plants while coal was cheap. Now that it's high, more Diesels will go in. They will be successful, for each year scores of men are being trained as oil-engine men. One advantage Europe has on us is her ability to secure technically trained men as watch engineers. Because of low wages, it has been easy, in Germany, to employ a technical graduate for around $60 per month. While technical training is not absolutely essential, there is no doubt that an engineering education gives a man the capacity for thinking logically and correctly. In my opinion the fact that a man has finished an engineering course, either at college or night school, proves he is made of good stuff. He is the kind that has the ginger to do things and is dependable. Without reflecting on you fellows, it would be fine if all of you had had such a training. Then a lot of things that seem beyond explanation to you would be as simple as rolling off a log.

"However, I congratulate myself that the men at most of the plants are far above the ones we had four years ago. In those good old days, as Kelly calls them, about the only recommendation we got with a new man was that he couldn't read or write but was a natural-born engineer. If we had no trouble, it wasn't due to their work but to the old chief's energy and to the low load carried."

"Well, J. R., I can't see why a college man is the thing for a Diesel plant. I never saw many college graduates around steam plants," said Kelly, who was ready to defend his own lack of engineering education.

"I didn't say that they were more needed in a Diesel plant than in a steam plant. In past days, coal was cheap, and to be considered a good engineer or fireman it was necessary to have a strong back, even though accompanied by a weak mind. A man was rated by the tons of coal he could throw into the firebox. Keeping steam up was the order of the day, with no thought as to the cost of that steam. But now things are different. Just glance over the 'want' column and see the demand for technical men, both for the boiler house and the engine room. Nowadays it requires brains to successfully run a steam plant. A

At the next meeting Egan will answer some questions asked him on matters of interest to the men.

steam plant does have one advantage. The outfit will limp along even though boiler tubes leak and engine valves are out of shape. So most anyone can make the wheels turn even though at a frightful cost.

"In a Diesel-engine plant things are a little different. The fact that the engine will deliver its rated horsepower is good evidence that it is producing its power fairly economically. It may almost be taken as an axiom that a Diesel engine can't produce power uneconomically. I can also make the claim that the engine must be in good mechanical condition to run at all.

"These two statements, which our experience proves are facts, show why a poor engineer will have what he calls bad luck in operating a Diesel. If he is ignorant of the engine's peculiarities, when little things happen he is stumped, and the engine stops. The operator usually has no time to experiment to find out what's wrong. He must know immediately what remedy to apply. For this reason a better-trained and more intelligent operator is required than in case of a steam plant. If a man has had a technical education, he can reason more logically. His years of study have given him an insight into the theory of combustion and principles of mechanics.

"Unfortunately, the rate of pay in the average plant, both steam and oil, is not high enough to attract the college man in this country. Even though the matter of pay is brushed aside, the chance of advancement usually is meager. The day is coming, however, when this state of affairs will be changed. It's going to become an accepted fact that oil-engine operation demands brains, and trained ones at that.

"You men who have been denied the chance of an education have one advantage. Your years of work have given you considerable mechanical skill. To my mind, the operators, or at least one operator in each plant, should be a skilled machinist. With a Diesel plant there is much work requiring a higher degree of mechanical skill than in a steam plant. The clearances are less. It is necessary to have the bearings turned truer and made of better metal. The adjustment of governor parts, as well as fuel mechanism, demand the attention of a man who recognizes the importance of a thousandth of an inch. In the matter of bedding a valve to its seat, one cannot be satisfied with the finish cut that is usually given to a Corliss valve. On the contrary, the finished surfaces must be perfect; the ground seats should be as true as the surfaces of a telescope lens.

"In the near future, the ever-increasing sale of Diesel engines is going to create a demand for high-class engineers. A poor 'monkey-wrench and cold-chisel' engigineer has no place in the Diesel engine room. This means greater opportunities and a higher value placed on your services. To meet this demand, you men should take up the study of mechanics and other engineering subjects. A correspondence-school course means hard labor after working hours, but if you ever hope to rise above the pay and rating of a watch engineer you must study."

"But hang it," Kelly broke in, "I don't think it requires a heap of knowledge to get along with a Diesel engine. Take the plant of the Gatesville Light Co. They are running that with a chief who was an automobile repair man, two engineers who never saw an oil engine a year ago, and two niggers. I don't see much book learning or even hoss sense in that crowd."

"I'm glad you mentioned that plant. It happens I have its record for last year. I also have the record of a Diesel plant, in an adjoining town, pulling the light and street-railway load. Now notice these figures:

	Gatesville	Other Plant
Pounds of oil per kw.-hr.	1.2	0.85
B.t.u. per kw.-hr.	18,870	15,725
Station load factor	0.50	0.85
Costs in mills per kw.-hr.:		
Labor	2.25	1.50
Fuel	4.50	3.20
Maintenance	5.00	0.05
Oil, waste, etc.	2.00	0.25
Total in mills per kw.-hr.	13.75	5.00
Station wages, monthly:		
Chief engineer	$100	$150
Watch engineers (2)	150	160
Oilers (2)	90	135
Total monthly labor expense	$340	$445

"Note the high fuel and maintenance cost of the plant using cheap labor. Some folks knowing the history of these plants might raise the point that the Gatesville engines are older and are not in good shape. This is true, but the fact they are not in good shape is due to the cheap labor that has run them ever since they left the factory. It is because of this labor that the load factor is so low. I've been in that plant at all hours of the day, and at no time was the load ever too large to be handled by one unit. Yet the inexperienced, poorly paid operators are afraid to put the load on one unit. So both engines are used to carry a one-engine load. The fuel costs are of course high, for the load factor is never more than 80 per cent. of a single engine's rating. The maintenance is high, since the units are run when they should be pulled out of service for a few hours. Instead of this, every Sunday is spent in useless repairing. I myself want intelligent and skilled help.

"You men should all subscribe to trade magazines. If each would take a different one, together you'd have most of the worth-while magazines published. By magazines I don't mean those published for the general public. In those, the attempt is made to write for the whole people, and of course the material is not very deep or accurate.

"Whenever you are near a power plant—steam, oil or gas—go visit it. You'll get lots of new pointers. Go over the plant and see where you'd change it—use your brains. In our own plant try to get at the reason for everything that happens. Ask questions. It's surprising how much you can learn from the other fellow.

"One class of men it will pay you to listen to with especial attention is the machinery salesmen, or, as they are called of late years, sales engineers. In the old days the usual machinery man dropped into the plant with a bottle in one hand and a cigar in the other. His stock in trade was his good humor and his shady stories. Of late years a new class of men are selling machinery. They know their business. I've gotten a lot of information from them. Lots of times their advice has kept me from making mistakes."

The use of big words is an old trick to inspire awe and respect. The label of a proprietary brand of clay poultice explains that this wonderful substance is "composed of the finest anhydrous and levigated argillaceous mineral," which expressed in language not "too good for the common people" would be simply "dried and finely powdered clay."

The Electrical Study Course—Testing Motor Efficiencies

Presents an outline of some of the methods commonly employed in the determination of motor efficiency. The brake test is then singled out for more detailed consideration.

THE lesson published in the issue of Dec. 24, 1918, described a method of testing the efficiency of motors without placing a load on them. As explained at the time, the method outlined does not give results of great accuracy. To determine the efficiency under the conditions actually obtaining when a motor is running under load, it is necessary to employ a different form of test, in which the mechanical output of the machine can be obtained. There are several methods by which this can be accomplished. Thus, the motor may be coupled to a generator whose efficiency curve has been previously determined; since the generator output is equal to its voltage multiplied by the current it delivers, it is a readily obtainable quantity, and since the efficiency at that load can be found from the efficiency curve, its power input can be computed. This input, being derived entirely from the motor, is therefore the mechanical output of that machine, which is consequently determined.

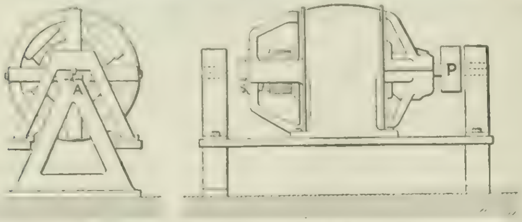


FIG. 1. DYNAMOMETER: GENERATOR FRAME SUSPENDED ON KNIFE-EDGES

Another method of measuring the efficiency is to measure the output by means of some type of dynamometer, a favorite form of which is a generator whose field frame is supported in such a manner that it is free to move concentrically about the armature as, for example, in the manner illustrated in Figs. 1 and 2. In the former the frame is suspended upon knife-edges *A* and in the latter by means of the bearings *B*.

The motor to be tested is belted to the pulley *P*, Figs. 1 and 2, in either case, causing the dynamometer machine to run as a generator. By varying the load connected to the generator the load upon the motor can be controlled. When current flows through the generator armature, it exerts a drag on the frame since its conductors are forced to cut through the magnetic flux of the field, and the degree of drag depends upon the amount of current. This drag tends to make the frame revolve, and by measuring the force required to keep it from doing so, the power transmitted to the dynamometer by the motor can be computed.

The figures are to be considered as merely representing the theory of operation and not as actual illustrations of the apparatus used. These types are known as transmission dynamometers, since they transmit the energy without expending it within themselves, barring, of course, the amount used in overcoming the losses in the dynamometer machine. That is, the energy of the motor is really used up in the lamps or other load that may be supplied with current from the generator. There are other types of transmission dynamometers, but they all have for their object the transmission, without absorption, of energy, coupled with means for determining the amount of power transmitted.

In contradistinction to the transmission type there is a class in which the energy output of the motor is entirely absorbed within the dynamometer. This type is nothing more or less than a brake that is applied to the pulley of the motor. That is, a brake test is made upon the motor as it would be in the case of an engine, for instance. In addition to the various methods mentioned in the foregoing, there are others that can be utilized when two like machines are available. In these one of the machines is operated as a motor and the other as a generator. They are connected electrically and mechanically, the arrangement being such that either the generator furnishes the current necessary to run the motor, or the motor furnishes the power necessary to drive the generator. The losses in the two machines are supplied either mechanically by a third motor of small size, or electrically from the supply mains. In either case the electrical output of one machine and the electrical input of the other are known, since they can be measured by means of voltmeters and ammeters. From these data and a knowledge of the losses, which are determinable, the efficiency of the machines can be computed. Of all the methods described, the one that adapts itself most readily for use under any circumstances is the brake test, and a more comprehensive explanation of it will be given than has been undertaken for any of the others.

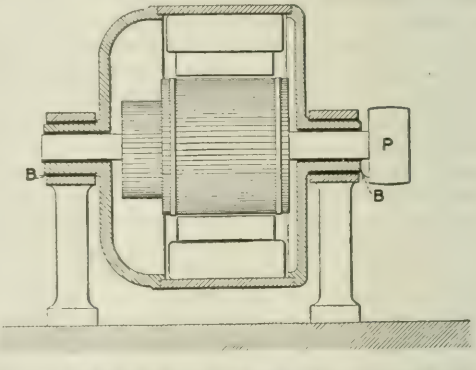


FIG. 2 DYNAMOMETER: GENERATOR FRAME SUPPORTED IN BEARINGS

To begin with, the object of any such test is to measure the mechanical output of the motor at the same time that the electrical input is measured, in order that its efficiency at the load it happens to be carrying can be calculated. Thus, if P represents the power output, P_1 the power input, and E_f the per cent. efficiency, we have $E_f = \frac{P}{P_1} \times 100$. If we let E represent the voltage at the motor and I the current taken by it, we have, the power input $P_1 = EI$, and consequently $E_f = \frac{P}{EI} \times 100$. The values of E and I can readily be determined by means of a voltmeter and an ammeter connected into the circuit. It therefore remains to find P.

Since the efficiency at various loads is to be determined, it is necessary not only that P should be capable of being computed, but that the adjustment of the load that gives rise to P should be under control. By applying an adjustable brake to the pulley of the motor this object can be accomplished. Before describing the types of brake commonly used, and the methods provided to obtain the observations required for calculating the motor output, some attention should be given to the construction of the pulley to be used.

When it is considered that the entire output of the motor is going to be consumed in friction between its pulley and a brake, it becomes evident that a great deal of heat is going to be generated, which will of course heat the pulley. If no provision is made to cool the pulley, it can readily reach a temperature that will scorch, and even ignite, the brake. At the same time much of the heat would be transmitted through the shaft to the bearing and to the armature, resulting in injury to the machine. It is therefore necessary to provide means for limiting the temperature of the pulley to a safe value. It is, moreover, desirable to maintain as constant a temperature as possible, as it will be found that the friction between the pulley and the brake varies with the temperature, making it a matter of difficulty to keep a constant load on the machine when its pulley temperature is allowed to vary greatly.

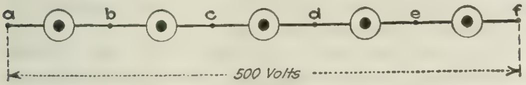


FIG. 3

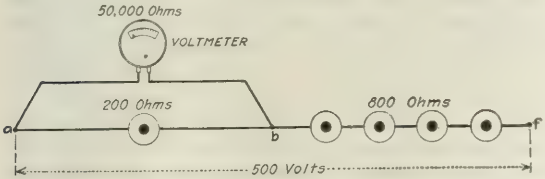


FIG. 4

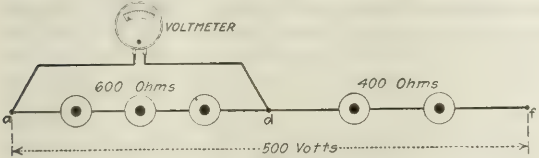


FIG. 5

FIGS. 3 TO 5. FIVE LAMPS CONNECTED IN SERIES

The details of the pulley construction and of the brake will be taken up in the lesson of next week.

The problem of the preceding lesson related to the voltages across five 50-watt lamps connected in series across 500 volts, as in Fig. 3. It was required to find the voltage actually existing between the points ab and the points ad, and to determine the discrepancies between these voltages and those that will be indicated by a voltmeter whose resistance is 50,000 ohms, when it is connected across the same points. Since there are five similar lamps across the 500 volts, there will be one-fifth of the voltage across each, or if E represent this voltage, we have, $E = \frac{500}{5} = 100$ volts. The voltage across ab is equal to E and is therefore 100 volts. That across ad includes three lamps and is therefore $3E = 3 \times 100 = 300$ volts. The current taken by the lamps can be found by dividing their input, namely, 50 watts, by the voltage across them. Hence, if I be assumed to be the current, we have, $I = \frac{50}{100} = 0.5$ ampere. The resistance of each lamp is equal to its voltage divided by its current. If R be this resistance, we have, $R = \frac{E}{I} = \frac{100}{0.5} = 200$ ohms. This would be the value of the resistance across ab, and that across ad would be equal to the resistance of three lamps, or $3R = 3 \times 200 = 600$ ohms.

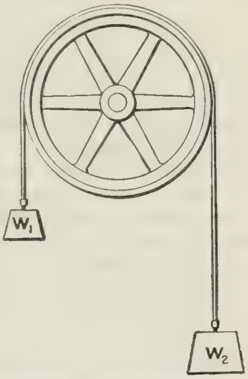


FIG. 6. TWO WEIGHTS SUPPORTED OVER A PULLEY

When the voltmeter is connected across ab, we have a resistance of 200 ohms connected in parallel with one of 50,000 ohms, the two in multiple being connected in series with the lamps between b and f, whose resistance is $4R = 4 \times 200 = 800$ ohms. When the voltmeter is connected across ad we have 600 ohms in multiple with 50,000 ohms, the two being connected in series with the lamps between df, whose resistance is $2R = 2 \times 200 = 400$ ohms. These two sets of conditions are illustrated in Figs. 4 and 5. Taking up the case of Fig. 4 first, let us represent the resistance between af by R, that between ab by R_1 and that between bf by R_2. We then have $R = R_1 + R_2$. To know R_1 we must find the multiple resistance of the resistances between a and b. Thus, we have, $R_1 = \frac{1}{\frac{1}{200} + \frac{1}{50{,}000}} =$ 199.20 ohms, from which, $R = R_1 + R_2 = 199.20 + 800 = 999.20$ ohms. The total current flowing will be this resistance into the total voltage; namely, 500 volts. Hence, $I = \frac{500}{R} = \frac{500}{999.20} = 0.5004$ ampere. If E_1 be the voltage across ab, we have, $E_1 = IR_1 = 0.5004 \times 199.2 = 99.68$ volts. Since the actual voltage, when the voltmeter is not connected in, is 100 volts, the discrepancy is $100 - 99.68 = 0.32$ volt, making the error 0.32 part in 100 parts, or $\frac{0.32}{100}$, which multiplied by 100 would give, $\frac{0.32}{100} \times 100 = 0.32$ per cent. error.

In the case of Fig. 5 we have, $R_1 = \frac{1}{\frac{1}{600} + \frac{1}{50{,}000}} =$ 592.885 ohms. Substituting in the value for R gives, $R = R_1 + R_2 = 592.885 + 400 = 992.885$ ohms, from which $I = \frac{500}{R} = \frac{500}{992.885} = 0.503583$ ampere. The voltage across ad will therefore be, $E_1 = IR_1 = 0.503583$

$\div$ 592.885 = 298.57 volts, and since the actual voltage without the voltmeter is 300 volts, the difference is 300 − 298.57 = 1.43 volts, which makes the error 1.43 parts in 300 parts, or $\frac{1.43}{300}$, giving an error of $\frac{1.43}{300} \times 100$ = 0.477 per cent.

The diameter of the pulley in Fig. 6 is 18 in., and it is to be driven by an electric motor, through reduction gearing, at 30 r.p.m. What size motor would be required to lift W_2 if its weight is 1500 lb. and that of W_1 is 300 lb.? (Assume that there is no loss of power in the hoisting system.)

Erecting and Testing an Engine in 1870

By D. W. Foster

It was a good many years ago that I helped to erect and test an engine having some points which I think will interest the readers of *Power*. In fact it was in the first months of the year 1870, and I was an articled apprentice in a Suisse works building many kinds of machines.

An engine had been sent from England and the directions for erecting and testing were in English, so I was detailed to assist a man by the name of Pasquet to do the work and translate the directions. The boxing was noticeable as all parts of them that had to be removed were screwed on and each screw was marked with a number and the directions said that these screws must be removed in sequence. I found that this system saved much time. The engine, after being tested, was to be reshipped in the original boxing.

When the box containing the piston rod was opened, Pasquet was astonished as one could see that the rod was sprung. The chief engineer was sent for and the rod was taken to a planer and laid in the platen and a surface gage showed that the rod was sprung about three-eighths of an inch, if I remember aright. Off went the chief to write to the builders, while Pasquet sat down on a stool and seemed to be thinking very hard. At last he called me and said, "What do the directions say about that rod?" I got the papers and the supposed trouble was made clear. Under the heading piston rod I read about as follows: "It will be noticed that the piston rod is cambered. On the crank end will be found a line marked *O*, this line must register with a line on the crosshead and the nut must then be set up; if this is not done, the camber of the rod would not point upward, and its value would be lost. We here explain that the idea of the camber is to take the weight of the piston from the lower side of the cylinder, thus preventing wear."

This was a new idea all around and Pasquet sent me to the chief to explain. He did not seem to take any stock in the system, but it was not his affair, so we followed the directions.

The next thing that was out of the usual was in the studding for the cylinder head. Two of these studs were about ½ in. longer than the others, why, we did not see until we came to put on the head. Then the reason was clear, as these long studs could be easily entered into the stud holes of the head and the head easily slid into place. This was the first time any of us had seen the idea, but I have often seen it since. The cylinder head was scraped to a joint. It was cast hollow and exhaust steam was led to the cavity by a copper tube and then to the condenser.

The piston was encircled by a band of copper holding the rings in place, and in the piston was another new idea. The rings were of the segmental type set out by flat springs. These were made of german silver or some whitish metal, and all were mounted in a U-shaped solid ring. On the back face of this ring was cut a ratchet the teeth of which engaged with a sort of plunger that passed through the back plate of the piston, and the end of this plunger came in contact with the face of the cylinder head at the end of the stroke, forcing it forward, thus imparting a slight rotary motion to the ring carrying the segmental piston rings. The idea of this was to prevent scoring the cylinder.

The front cylinder cover was cast hollow and piped, as was also the back head. Metallic packing was used in the stuffing-box, and it was the first I had ever seen. It was very long, at least 14 in. and had grease rings fitted between each section of packing, which was made up of a double cone split horizontally and two solid rings bored to fit the tapers of the cones. These were of some soft metal, and the rings were of cast iron.

The pillow blocks were of composition, scraped to a fit on the two sides parallel to the shaft, but instead of the bottoms bedding down, as we had always been used to seeing, a new construction was used. A wrought-iron plate was machined and fitted to the bottom of the pedestal opening for the pillow block. In the middle of this piece was machined a rounded score at right angles to the shaft, with a radius of perhaps two inches. The bottom of the composition pillow block was machined in the same way, and between the plate and the block a piece of turned and hardened steel shafting was placed, this giving a certain amount of adjustability to the bearing.

Oiling the crosshead slides and gibs was effected in a new way, so far as we knew. The crosshead guides were wide and the shoes were long. The guides were cast hollow, and holes were drilled from the faces into the cavities. These holes were staggered, and about six on each side. Into these drilled holes were fitted composition cylinders in which were glass balls, or marbles. A shoulder prevented the balls from rising more than ⅛-in. above the surface of the guide when the cylinders were in proper position, and the balls were held up against the shoulder by a spring. When the crosshead shoe passed over the balls, they were of course depressed, but when the shoe had left them the spring closed the opening; that is, the ball rose up against the shoulder. As the cavity in the guides was supplied with oil from a tank suspended about two feet above the guides a pressure of approximately two pounds was obtained, so we had a forced-feed oiling system.

The valves were of the Corliss type, but were peculiarly made, as they were segments of a circle equal to the bore of the cylinder. This was done to reduce clearances. Just how these valves were made in detail I do not remember.

How well the engine stood the test of long wear I do not know, but the shop tests were very satisfactory and the economy was much better than any of which we had any record. I think the engine was built by Merlie & Tate. These people built sugar machinery. At any rate the work on the engine was as good as could then be obtained in the world, and not a file was required to bring the parts together. I may add that the engine cylinder was about 36-in. diameter and 48-in. stroke.

EDITORIALS

Edison Medal Presented to Benjamin G. Lamme

THE American Institute of Electrical Engineers has this year awarded the Edison Medal to Benjamin G. Lamme. The award was made for singular and distinguished accomplishment in the "Invention and Development of Electrical Machinery." Thus the year's crowning honor in electrical work has been paid to a designing engineer, for it is as a designing engineer that Mr. Lamme has preëminently worked out his genius.

His work has been so varied and his versatility so great that a detailed mention of the developments in which he has been concerned might be mistaken for a history of the art of the design of electrical machinery. There are certain landmarks in his work that are of more than passing interest to the electrical fraternity.

In the field of power generation and transmission the first generators that transformed the power of Niagara into electrical energy were his work, and in connection with this power house the use of twenty-five cycles, alternating current, for heavy power work was established. Following related designs, this general type of machine reached its climax in the old Manhattan engine-type machines, giants of their time, standing somewhat over forty feet high. Realizing the possibilities of the steam turbine, Mr. Lamme set himself with equal determination to the development of the modern high-speed turbo-alternator, which reaches today in a single unit capacities many times the old Niagara or Manhattan machines and in a fraction of the space required by either.

In the railway field he has been associated with the development of the railway motor since its conception. He has been of later years so much connected with alternating-current apparatus and developments that it is a matter of wonder to look back twenty-five years and find that the same man was responsible for shaping the design of the direct-current railway motor along such lines that the motors of that time bear a startling resemblance to the direct-current railway motor of today.

In the industrial field Mr. Lamme's greatest contribution is the development of the induction motor. Working with Mr. Westinghouse, he took Mr. Tesla's ideas and reduced them to a piece of apparatus which in the squirrel-cage type is recognized to be the simplest possible machine for the conversion of electrical into mechanical energy.

In connection with the American Institute of Electrical Engineers Mr. Lamme has rendered signal service to the electrical art. In 1912 and 1913, when the A. I. E. E. standardization rules were under consideration for revision, the ablest men in the electrical profession in this country sought for some time for a basic principle, some simple fundamental which should serve as a keynote in making a change so important as this change in the recognized electrical standards of a nation. Many ideas had been proposed and rejected when Mr. Lamme formulated the conception that such a change should look into the future and cover, so far as human vision permitted, the practice of the years ahead rather than simply to recognize and give authority to the practice already developed and concerning which there naturally exists some difference of opinion. This idea at once cleared the air of controversies in degree similar to those of the present peace conference and established the basis upon which the present revised rules stand—a monument to the saneness of their framers.

No mention of Mr. Lamme's work is complete unless it touches his interest in young men and his service in the training of the graduates of technical schools for their work in practical design and manufacture. This interest is broader than the plain estimation of the young man's technical brain and its development; it concerns as well a broad human sympathy and an interest in the young man's character and personality which is repaid by a warmth of loyalty that has no measure in the ordinary relations of a commercial organization.

Heat Balance, United States Nitrate Plant Number Two

IN THE design of a modern power plant reliability has first place. Securing this, the engineers devote themselves to detailed studies to the end that the unit output will be had at the highest efficiency and the lowest cost. American engineers have long been striving to deliver to the switchboard a kilowatt-hour of electrical energy per pound of coal burned. In recently designed stations, favored with good coal and adequate and cool condensing water, this figure has been more closely approached than the most optimistic would some years ago have dared to believe. A curve, showing the decrease in coal consumption per kilowatt-hour for representative stations, plotted against years, reveals the markedly favorable influence of the steam turbine, of stoker and boiler improvements. To lower the curve below the point where the modern turbine puts it requires of the engineers wide and up-to-the-minute knowledge as to design, and consummate skill in operation.

The reader therefore will appreciate Mr. Lockwood's article elsewhere in this issue, which treats of heat-balance studies of the United States Nitrate Plant Number Two, with the design of which he and E. R. Welles and William Shoudy, of the J. G. White Engineering Corporation, had so much to do. This plant, a war plant, designed and built in a great exigency, has commanded the attention of engineers the world over. Distinguished engineers who have visited it have become absorbed in studies of it and have come away impressed by the achievement. Several articles in recent issues of *Power* have described the station. The one in this issue tells what it was designed to do in the way of performance. No need in this column to give figures—the article is replete with them. In them American engineers have reasons for gratification.

Report of the Prime Movers Committee

"THIS Committee's report is not so much to tell what has been developed during the war as to state what has been done despite the war." So did N. A. Carle, chairman of the Prime Movers Committee of the National Electric Light Association, introduce the committee's report at the recent convention of that body in Atlantic City. The statement fits the situation, for the difficulties of labor, materials and transportation were indeed great. That the industry surmounted them so well is concrete evidence of the excellence of its engineering personnel particularly.

Though a whole afternoon was devoted to discussing the report, as usual several subjects were not touched upon. This committee is one of the most important, if not the most important, of the National Electric Light Association, and again this year it was evident that too little time is available for consideration of its report in convention assembled.

He who attended the meeting in the hope that he might hear or participate in discussion of the specific troubles which the large turbine has developed during the trying period of the war was disappointed. Of course few expected such discussion, but it was gratifying to hear the expressions of confidence in the large single-shaft turbine by the leading engineers of America's great power stations.

The committee said that, " . . . with the present constructional problems of prevailing frequencies and speeds and the recognized factors of safety, efficiency and cost, the size of the systems today will hardly warrant units larger than thirty thousand kilowatts capacity. In particular cases, and until increased reliability, as well as improvements in operating efficiencies, have been established, even larger systems will not justify the use of larger units." While on the whole the last statement finds support, the discussion by W. B. Finley, superintendent of motive power, Interborough Rapid Transit Company, New York, in which he told of experience with the operation of three thirty-thousand and one sixty-thousand kilowatt units, would indicate that, for his conditions at least, with the large units the performance is such as give the highest sense of security against interruptions due to faults within themselves. Mr. Finley pointed out that, compared with the capacities of both the Seventy-Fourth and the Fifty-Ninth Street Stations, 195,000 kilowatts for the former and 205,000 for the latter, a thirty-thousand kilowatt unit is really a small one. Mr. Finley is confident that the troubles that have developed in the large single-shaft machines at Fifty-Ninth Street will be eliminated. Moreover it is significant that the builders of such machines, while bringing to bear the great resources of their research departments to obviate certain defects, do not contemplate any radical departure in type.

We believe that W. L. Abbott, chief engineer, Commonwealth Edison Company, Chicago, expressed the thought of many when he said before the meeting, "We may confidently contemplate the use of turbines larger than we have been using in the past. . . . We may gradually rely upon units of larger proportionate size to the total station capacity than we have in the past."

A pleasing announcement was that made by Philip Torchio, New York Edison Company, who said that the Power Station Committee of the American Institute of Electrical Engineers had secured the cooperation of builders of large turbines in the preparation of papers on the design of large turbines. He expects such papers to be presented before the coming October meeting. Of course all interested look forward to something unusually comprehensive in these papers. Perhaps this is the beginning of that real coöperation between designer and user which Mr. Sniffin, of the Westinghouse Electric and Manufacturing Company, again so admirably urged before the convention.

I. E. Moultrop will find unanimous acceptance among engineers of his suggestion to the committee that to really get somewhere with the use of higher steam pressures, manufacturers of power-plant equipment build a two-thousand or three-thousand kilowatt experimental station, using the pressures anticipated. Certainly, this is a quick way and surely one of the cheapest ways of finding the practicable limitations of high steam pressures.

The one regrettable feature of the report and discussion of it was the total lack of anything on water power; but the committee explained that this was unavoidable.

Misleading Plant Statistics

IT WOULD be hard to name a simpler task in plant statistics than to keep a periodic record of the rated capacity of the installation, and yet a recent examination of operating data from about a dozen otherwise well-run stations disclosed an amazing laxity as to the size of the plants at various dates. The records examined covered a five-year period, each group of plant sheets purporting to show all the important operating and cost data of a given year. Provision was made on all the forms for recording the number and ratings of each generating unit, with other physical plant data, loads, etc.

Some of the sheets failed to distinguish between kilowatt and kilovolt ampere ratings of units, putting down the plant capacity one year under the former and the next year stating it as the same rating under the latter classification. Probably this was due to ignorance on the part of the staff of the accounting departments, which was in the final analysis responsible for the data set forth, but as these records were prepared and filed with a long-established state commission, it is a pity that there was not an engineering check on the information spread before the authorities.

Complications arose, too, from the failure of those preparing the record sheets to state the dates on which certain generating units were withdrawn from service to permit the installation of larger sets in their places, and again, in some plants the direct-current side of one or more motor-generator sets was added to the kilowatt or kilovolt-ampere rating of the units driven by prime movers directly.

A weak spot in station data will be found in many plants undergoing extensions or remodeling with regard to the fitness of various units for service at given dates, as it is sometimes important to be able to testify that the capacity of a station at a particular date was exactly this or that figure. These and similar matters are often entirely overlooked, so that it sometimes becomes necessary to answer with an estimate based on memory questions that should be as clearly and definitely settled by fully recorded data as engineering rating practice now makes possible.

· Correspondence ·

Using Steam in Hot-Water Radiators

Those having to do heating work know that hot-water radiators can be used for steam heating but that steam radiators cannot be used in hot-water heating, as the latter are connected at the bottom of the sections only, whereas the former are connected at both the top and bottom. The reason why more hot-water radiators are not used in steam work is because the steam radiators are slightly cheaper and more easily repaired; probably there being fewer joints is another reason.

Heating engineers design many systems in which the pipework may be used for steam heating, but engineers who do their own work sometimes put it over the heating expert by putting up a job that the latter will condemn as unworkable.

Such a system is shown in Fig. 1. The job is really in practical use; it is noiseless in operation with either low or high steam pressure. Hot-water radiators are used throughout and where connected as shown, the automatic air vent is placed at *B*, which is the steam-entrance end. This is directly opposed to the usual way, as when the radiator is connected at the bottom on both ends the air vent is placed at *C*. The building is three stories high with a straight riser, a drip being placed on the low end of the main in the cellar. Radiators are on each floor and appear to give good results whether connected at the top or at the bottom on the inlet end.

A 2-in. pipe runs to first-floor radiators, a 1½-in. pipe to second and 1¼-in. to third. Some are floor and others are wall radiators. I have turned steam into this system at both low and high pressures, but in the latter case I let the steam enter slowly, the pressure being 60 lb. gage. In every case the system heated up with no hammering and was practically noiseless.

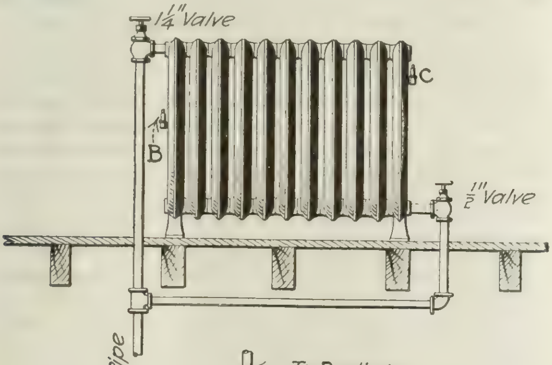


FIG. 1. HOT-WATER RADIATOR PIPED FOR STEAM

There are no water seals or loops. The returns pass through a V-notch meter, and the water is pumped back to the boiler.

Fig. 2 shows the run of the mains in the basement. Exhaust steam is generally used, the pressure being so low that it will not move the gage hand away from the pin. A reducing valve was connected to be used when no exhaust steam was available, but the pressure in the system was so low that this valve allowed a small quantity of live steam to pass even when the exhaust was in use. It was therefore removed and a 1-in. hand-controlled valve connected in the line in the boiler room.

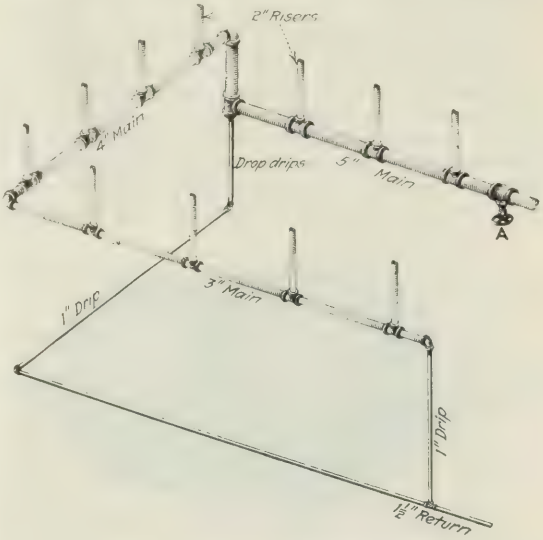


FIG. 2 RUN OF BASEMENT MAINS

The valve *A*, Fig. 2, was put in a convenient place for the people in the building to close off the steam without going to the boiler room when either exhaust or live steam was being used. Suitable back-pressure and relief valves were arranged in the boiler room to take care of the exhaust steam if it should be cut off in the building.

In one-pipe jobs with only one connection to each radiator there is generally considerable crackling noise when the steam is turned into an empty system; in the job herein described there is practically none of this noise.

In another job the radiators are all of the steam type and are connected at the bottom and at each end, with one riser to the three flats. They work equally well with low pressure, but not so well with high-pressure steam, as in the latter case the water of condensation seems to be held back somewhat in the radiators. It does not "pound," but makes a disagreeable gurgling noise. This latter job has been in use for fourteen years and has never given any serious trouble outside of the noise mentioned.

James E. Noble.

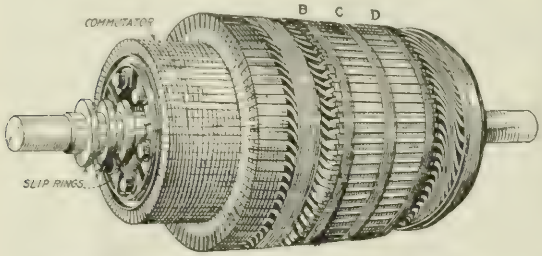
Kingston, Ont., Canada.

Heating of Banding Wires on a Self-Excited A.-C. Generator

Recently the center band on a three-phase 25-kv.-a. 230-volt self-excited alternator in our plant broke. This band consisted of No. 20 steel piano wire and was $\frac{5}{8}$ in. wide, as were the other two core bands, and located on the armature as shown at *C* in the figure.

The band was renewed in the customary manner, using the same kind of wire. The armature was replaced, the clearance between polepieces and armature checked and found to be all right, so the machine was started and run up to full speed. After running for about three minutes without load, the center band suddenly burst.

A careful examination failed to reveal the cause, but did, however, indicate that the solder had been thrown off this band previous to its bursting. Another band was carefully put on and the generator again started up, but with no excitation, and no trouble was experienced on a thirty-minute run. With excitation, however, the machine was operated but one and one-half minutes, and upon shutting down it was found that the center band was very warm and had started to melt solder at various places. The other two core bands were also warm, although the armature proper had not increased in temperature. A magneto test showed that all three bands were electrically connected to the armature core, thereupon the bands *B*, *C* and *D* were removed, the portion of the core underneath them was thoroughly painted with insulating paint, and three new bands were installed over insulating paper. These were tested out for grounds on the armature and found to be clear.



ARMATURE OF SELF-EXCITED ALTERNATOR

As before, the armature with full excitation could be run only about one and one-half minutes before the bands heated up. From this it appeared that eddy currents induced in the banding wires were responsible for the heating.

The remedy which suggested itself was either to cut down the amount of magnetic material in each band or to use a nonmagnetic conductor for the bands. Not having the nonmagnetic material at hand and it being imperative that the machine be put in commission, the only solution was to reduce the area of the bands. This was done by cutting out the center portion of each of the three bands so that instead of each being $\frac{5}{8}$ in. wide there was a $\frac{3}{16}$ in. band, then $\frac{1}{4}$ in. space and then a $\frac{3}{16}$ in. band. This cured the trouble, and the machine has ever since been operating satisfactorily with these bands.

The specifications were obtained from the manufacturers of this machine, and it was learned that the original banding was of No. 20 phosphor bronze wire, each band being $\frac{1}{2}$ in. wide with three clips. Evidently, the steel bands had been installed about a year ago, when the armature was repaired.

I would like to hear from some readers of *Power* why the steel bands had been successful for a year and were unsuccessful when renewed with slightly narrower bands of the same gage wire and the same number of clips. I have never seen the foregoing explained or even mentioned in any book dealing with troubles of motors and generators. This experience may help someone else out of similar difficulty and any discussion will undoubtedly be of value to many operators. C. D. CORWIN.

Groton, N. Y.

Replacing a Boiler-Feed Valve

About five years ago I had charge of a hotel in Chicago where there was but one boiler and that was a low-pressure one for heating the building. It was fed from the city water supply as the water pressure was high enough to feed it at the highest steam pressure the safety valve would allow.

After I had let some water into the boiler one day, I tried to close the $\frac{3}{4}$-in. stop-cock, but it broke in half. The head of the plug went straight up and of course the water also. The check valve was between the cock and the city main, and I had both hot and cold water coming out at the one opening, and there was no way to shut off either one in the boiler room. I called to the cook, who was across the hall, to shut off the city supply valve in the kitchen, which he did, but as I had five pounds steam pressure on the boiler it only made matters worse. I still had plenty of water, but oh, so hot! I had to have the cold-water valve opened again enough to keep from getting scalded.

I had a pocketful of waste and a screwdriver, so I started packing the waste into the hole, and when it was full I got a furniture clamp from my tool box and screwed it on as tight as I could and stopped the water so it didn't leak a drop. This happened on Sunday, and I didn't have another stop-cock to replace the damaged one and there wasn't room enough for a valve. I went to some other hotels to try to get one, but no one had any. There was plenty of water in the boiler to last over until Monday, so I decided to let it go at that.

On Monday I got a new stop-cock from a supply house, but another problem confronted me: How could I put it on without draining the boiler? It was "good and cold," about 10 above. I thought out a plan and it worked fine. I raised two pounds steam pressure, then closed all drafts and opened the flue doors. A vacuum was thus created in the boiler, so that when I opened a gage-cock air was drawn in. I then put the new stop-cock, with a check valve between it and the boiler, on a piece of $\frac{3}{4}$-in. pipe about four feet long, so I wouldn't have to get my hands in the hot water again. I next took off the broken pipe. Some water came out, but with only a little pressure, so by taking the pipe that I had the valves on by the end, I caught the threads all right. In a few minutes I had steam on again and no one lacked heat.

I am passing this on, but hope no one will have a similar experience. JOHN D. COOPER.

Chicago, Ill.

Engine Crosshead Pounds

I have a 20¼ x 48-in. Corliss engine the crosshead of which is of the regular style with a key adjustment. When running, a loud knock is present in the crosshead, but only on the outward stroke, which increases when the boiler pressure is increased. It is necessary to key up on these crosshead brasses every other morning and sometimes every morning. If there is only a slight knock in the morning, it is sure to be bad by noon. The engine runs under and makes 81 r.p.m. The accompanying diagram is from this engine, taken with a 40 spring, boiler pressure 80 lb. I will be glad to have readers of *Power* tell me how to overcome my trouble. **E. Hollis.**

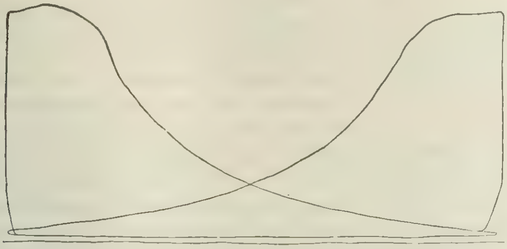


DIAGRAM TAKEN FROM POUNDING ENGINE

Mt. Olive, Ill.

[A little more compression would doubtless help matters.—Editor.]

Marine Engine Bearing Leads

The following incident in connection with the overhauling of marine-engine bearings, at a time when so many young engineers are entering this field, may be of assistance.

A chief engineer in the service of a well-known shipping company was transferred to another of the company's steamers with a view of overcoming the serious trouble that had been experienced due to pounding bearings.

On being taken aboard the ship and introduced to the retiring chief by the superintendent engineer, the "leads" taken from the crank and crosshead bearings were shown to him for his information and future guidance. Because of long experience with different types of engines, he at once came to the conclusion, on account of the thinness of the wire, that the leads were either faked or improperly taken, and expressed an opinion as to the possibility of operating any marine engine with the brasses so finely adjusted. While being shown around the engine room, he requested the second engineer to take "leads" from the high-pressure engine crosshead bearings. The engineer at once moved the engine, by means of the auxiliary turning engine, until the high-pressure crank was on the bottom center, when he removed the crosshead caps and brasses, inserted the pieces of lead wire ($\frac{1}{16}$ in. thick) and screwed the nuts down to the same marks at which they were previous to loosening them.

On loosening the brasses and taking out the leads they were found to be identical with the ones in the chief's office. The new chief then asked the engineer to turn the engine while he placed his hand on the crosshead block and guide, and immediately he felt the upward movement ordered him to stop. On taking off the "leads" this time, it was found that the top brasses had barely touched the wire.

The crank bearing of the same engine was then tried and the second engineer, following his usual method, turned the crank exactly on the top center and the "leads" secured were the same as the sample shown. He was asked to move the engine off the top center quite a bit and then move it back again until the chief decided it was near enough the top, and by feeling the crosshead block knew it still carried the weight. The "leads" now showed the crank brass was barely touching them.

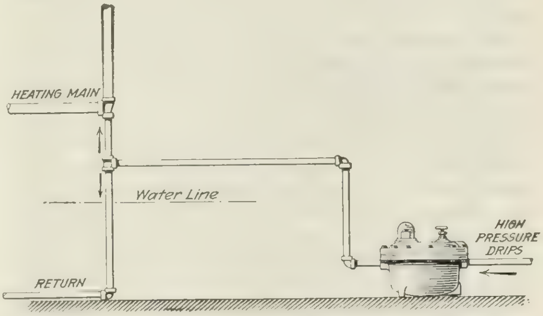
The same procedure was carried out with the other engines with the same results.

The mistake was made, of course, by overlooking the fact of the piston hanging up in the engine cylinder at the ends of the stroke, clear of the pins, and the flattening of the lead wire was made in pulling the piston down. **W. G. Gray.**

Medicine Hat, Alberta, Canada.

Piping High-Pressure Trap Discharge to Heating System

One bane of an engineer's existence is leaky traps. I have tried many kinds to find the one that will stay tight and do the work. In every case some heat escapes in the form of vapor due to the release of the hot water at the pressure at which the trap is working; and in order to get the benefit of this vapor, I discharge it, during the winter, into the heating system. This is easily done by connecting the vapor pipe of the drip tank, if there is one, with the heating system and placing a stop valve on the vapor pipe leading to the atmosphere, so it can be closed in winter and opened in summer. If there is no drip tank, the connection should be made to a steam riser, above the water line of the heating system, so that the vapor will ascend into the heating system and the water gravitate to the return pipe. The illustration is intended to show how the connections should be made. In case the trap should blow through or the bypass be left open by a careless attendant, the steam is not wasted, as it goes into the heating system and less steam has to be passed through the reducing valve. **W. T. Meinzer.**



TRAP AND PIPE CONNECTIONS

Brooklyn, N. Y.

Right-Hand and Left-Hand Fans

In his article on "Fans and Blowers in the Power Plant" in the issue of Feb. 4, Mr. Strohm states that the discharge of a blower is designated as right-hand or left-hand by facing the pulley and noting the side the exhaust is on.

This is contrary to the Government specifications, in which it is stated that in designating the discharge of ventilating sets the hand will be determined by the side on which the motor is mounted when the observer faces the discharge side of the fan and when the fan is standing on the deck. Thus, a top 45-deg. up discharge, left-hand, delivers air upward at 45 deg. toward the observer and the motor at the left operates with a clockwise direction of rotation. I should like to know whether there is an actual difference in stating the hand of a blower for commercial and Government uses. EARL M. FEHRLIN.

Elizabeth, N. J.

[Fan manufacturers do not agree on the method of determining the hand of a fan or blower. Some of them follow the Government specification given by Mr. Fehrlin and others use the method stated by Mr. Strohm in his article. In view of this lack of uniformity, the relative positions of the discharge outlet and the driving pulley or motor should be so clearly stated that no confusion can arise.—Editor.]

Pointers on Pumping Hot Water

The article by M. A. Saller, "Pointers on Pumping Hot Water," page 212 of the Feb. 11 issue, is well worth reading and the admonition not to inject cold water into the hot-water line is the right "dope."

I recall a small plant in which a very efficient method of collecting and feeding returns was used and this hot water all passed through a duplex pump. I have seen the feed-water thermometer registering 240 deg. F. at this plant and steam blowing from a pet-cock on the pump discharge, yet the pump never skipped a stroke.

The returns were taken from several high-pressure heating coils used for drying purposes, and the returns were collected in the ordinary cast-iron receiver, with a duplex pump attached. This receiver was not over six inches above the discharge deck, yet the pump worked wonderfully well. The receiver was not vented to the atmosphere ordinarily, but worked under from 10 to 15 lb. pressure. A check valve was tapped into the receiver to let in air if the pressure fell below atmosphere, which it might do if a machine was started with the coils full of cold water.

The engineer in charge said that he had instructed the operators to blow the cold water all out of the system before starting a drier, but once in a while one fooled him, so he put the check valve in to handle the condition.

Every piece of apparatus was equipped with a modern trap, and examinations of the valves were made at regular intervals. They had a hot-water heating system and used live steam at night, passing it through a heater which was within 25 ft. of the pump and about 8 ft. above it. A modern trap was connected to the 2-in. discharge line from the heater, and this discharged into the receiver. A maximum pressure of 60 lb. was turned into the heater, and the condensate, after going through the trap, receiver and pump, showed a temperature of 260 degrees.

The engine exhaust heated the raw water through an induction heater to about 140 deg. The engine operated compound condensing. Then the feed water went through a second heater fed by the auxiliaries, steam air pump, feed pump, circulating pump, etc., and left there at from 190 to 200 deg. The water then entered the receiver and mixed with the condensate and was finally pumped to the boilers.

The secret of the excellent running of the pumps was due to the following: The engineer never vented them to the air, but made the pressure keep the cylinder full of water. He never used metal valves as he could not pump water much over 212 with them, but employed a fibrous type of valve, which remained tight. The pistons were also kept in good shape.

The six pumps were all of the piston type. Once in twelve or fourteen months he put in new linings, pistons and rods. He was then able to pump the water at a high temperature. His theory was that if the piston leaks a little the water squeezes by at a pressure of about 135 lb. into a pressure of perhaps 6 or 8 lb. and the water, at high temperature, flashes into steam and then the pump is "steambound." That is all the secret there is to it.

I saw the performance of these pumps and can say that I believe the suggestions given are worth carrying out. C. W. PETERS.

Boston, Mass.

Running Steam Engines with Compressed Air

It is sometimes possible or desirable to operate steam engines with compressed air in the event that no steam is available and compressed-air service is to be had. This is often the case on the test floor of a machine shop, on construction work where compressed air is used or in the case of ships in dry dock where the boilers are shut down and it is desirable to operate the ship's dynamo to furnish light.

Small and medium-sized steam engines will operate very well and can be used for an indefinite time on compressed air if the pressure is suitable. Ordinarily, there need be no change in the setting of the engine valves. Simply connect the air service to the steam pipe of the engine and use air instead of steam. It is often desirable to disconnect the exhaust system of the engine so that it can exhaust directly into the atmosphere, thus eliminating back pressure.

In expanding in the engine, the air takes heat from the cylinder walls, thus cooling these parts to a considerable degree below the temperature of the atmosphere. While a certain amount of water is usually carried into the cylinder with the air and will assist in lubrication, it is well to arrange for more certain cylinder lubrication than this. Thick cylinder oils such as employed for steam service should not be used, for they are intended for use in a heat which will thin them somewhat and if used with air the cold will render them less fluid. Practical experience has shown that common machine oil such as used for bearing lubrication gives satisfaction. V. A. LYMAN.

Balboa, Canal Zone.

Inquiries of General Interest

Angularity of Connecting-Rod—What is meant by angularity of the connecting-rod of a steam engine? H. G. S.

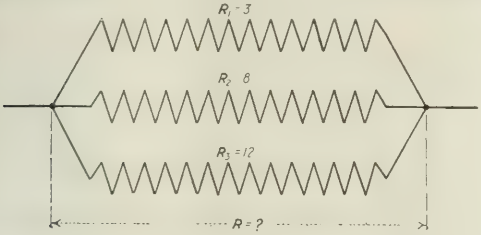
The term refers to the angular position of the rod at any time when the center line of the rod, passing through the center of the crank and crosshead pins, is at an angle with the direction of stroke of the piston.

Inspecting Leakage of Closed Feed-Water Heater—How can it be known whether a closed feed-water heater is leaking? J. N.

Leakage of a closed exhaust-steam feed-water heater will be revealed by a discharge of water along with the exhaust, especially from the drips. The best test of leakage is to observe whether there is discharge of water from the drips when the feed pump is operated without the engine or other exhaust discharging through the heater.

Joint Resistance of a Circuit—If three resistances, of 3, 8 and 12 ohms respectively, are connected in parallel, what is the joint resistance of the group? R. G. S.

The joint resistance of a group of three resistances connected in parallel as in the figure, may be found from the formula, $R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$ where R equals the joint resistance; and R_1, R_2 and R_3 the respective resistances.



In this problem $R = \frac{1}{\frac{1}{3} + \frac{1}{8} + \frac{1}{12}} = \frac{1}{\frac{13}{24}} = \frac{24}{13} = 1.846$ ohms.

Efficiency of Boiler, Furnace and Grate—What would be the percentage of efficiency of boiler, furnace and grate obtaining an evaporation equivalent to 10.95 lb. of water from and at 212 deg. F. per pound of dry coal containing 14,645 B.t.u. per pound? A. D. K.

Expressed as a formula, efficiency of boiler, furnace and grate =

$$\frac{\textit{Heat absorbed by boiler per pound of fuel fired}}{\textit{Heat of perfect combustion per pound of fuel}}$$

As evaporation of a pound of water from and at 212 deg. F. requires 970.4 B.t.u., the heat absorbed by evaporation of 10.95 lb. would be 970.4 × 10.95 = 106,258.8 B.t.u. and for coal containing 14,645 B.t.u. per pound, the efficiency of boiler, furnace and grate would be $\frac{106{,}258.8}{14{,}645} = 0.7255$, or $72\frac{55}{100}$ per cent.

Relative Stresses of Girth and of Longitudinal Seam—Why is the girth seam of a boiler twice as strong as the longitudinal seam? N. R.

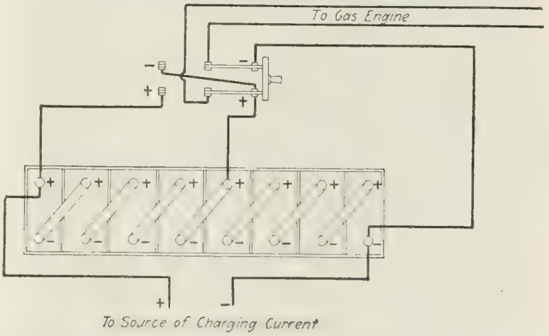
The strength of a joint is no greater because it is used as a girth seam, but the stress pulling the joint apart is only one-half as much per unit length of a girth seam as per unit length of a longitudinal seam. As an example, suppose a cylindrical shell to be 72 in. in diameter. Then the whole length of a girth seam would be 72 × 3.1416 = 226.195 in. The gross area of a head 72 in. in diameter would be 72 × 72 × 0.7854 = 4071.5136 and each pound pressure per square inch would cause a stress of (1 × 4071.5136) ÷ 226.195 = 18 lb. per inch length of the girth seam; but for 1 in. length of a longitudinal seam, each pound pressure per square inch would cause a stress of ½ of (1 × 72) = 36 lb., or twice as much as the stress per inch of length of the girth seam.

Trouble from Steambound Feed Pump—What causes a feed pump to become steambound, and how can the trouble be overcome? R. N. A.

A leaky check valve at the boiler and leaky pump valves and piston packing may allow hot water to work back into the water end of the pump when it is standing still or moving at a very slow speed. To restart pumping, stop the pump and open the drain cocks on the water end and leave them open until water is discharged by them, free from vapor, indicating that the water end is filled with water. Until the leaky parts are made good, close the boiler-feed stop valve whenever the pump is not required. When pumping hot water, the pump may become steambound because the suction lift is too great, resulting in such low pressure on the suction stroke that the hot water bursts into steam, which prevents the cylinder becoming filled with "solid" water. The trouble can be reduced by injecting cold water into the suction. But the only sure remedy is to place the pump low enough for the suction water to be delivered under sufficient head for keeping the pump cylinder filled with water at a higher pressure than that at which water of the temperature would vaporize.

Battery for Sparking Gas Engine—We have a 16-volt storage battery that I would like to use for ignition purposes. The gas engine requires only about 8-volt current. Can a resistance be connected in series with the battery, so as to cut the voltage down to about 8 at the coil terminals, and use it to spark the engine? The battery is charged from a low-voltage generator. L. K.

It is doubtful if satisfactory operation can be obtained by connecting a resistance in series with the storage battery. A better scheme would be to connect the battery through a two-pole double-throw switch, as shown in the figure, so that four of the cells can be used at a time for ignition purposes. With this scheme the battery may be charged at any time, even when part of it is being used to ignite the engine.



[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Salary Schedules and Employment Discussed at A. A. E. Annual Convention

At the annual convention of the American Association of Engineers held May 12 and 13 in Chicago, salary schedules, employment problems and opportunities, proper compensation and society inter-relations were the main features discussed. Ninety delegates from thirteen of the chapters and three clubs were present, although the attendance was 186 at the largest session.

With reference to salaries, A. M. Van Auken, chairman of the committee on compensation of the Chicago Chapter, presented a comprehensive 19-page report containing schedules of salaries for the various engineers employed in municipal, railway, highway, public utility, rural and other fields. The committee took the stand that the profession of engineering, taken as a whole, was insufficiently paid or was not paid in proportion to the high degree of responsibility entailed or the technical training required to perform the work. It was their opinion that the principle of a square deal for everybody should underlie all rules of compensation and that technical men must demonstrate their work both to their employers and the public before they receive the compensation due them. In the determination of this compensation consideration must be given to the effort or cost of the educational training, the years and character of experience in the particular line, as well as total years' experience, length of time in employer's service, character and personality, degree of efficiency and special qualifications. The uncontrolled law of supply and demand was not deemed a just method by which to determine the compensation for valuable services. The committee made a number of specific recommendations such as limiting the time of work to eight hours per day or 44 hours per week, recommending an increased rate for overtime, the observation of national holidays, and the payment by the employer of moving expenses when the place of employment was shifted.

F. H. NEWELL

Adoption of the report was not asked for, but it was recommended that the national body use the data in a nation-wide study and seek to formulate a more comprehensive schedule. A recommendation was adopted providing that abstracts of all laws applying to engineers and surveyors, which degrade or harm the engineer, be collected and published along with suggestions for better laws in the interests of the public and for the good of the profession.

In the employment department F. H. Myers indicated that 10 per cent. of the dues is now spent. From 300 to 350 members were on the list to receive the bulletin of positions open. Circular letters to employers gave 5 per cent. returns. For the week ending May 10 twenty-one men had been placed in positions averaging $150 per month at a cost of $45, as compared to $1890, the figure employment agencies would have demanded for the same service.

Changes in the constitution were as follows: A national practice committee is authorized to report on questions of ethical policy and conduct; a grade of "candidate junior" is added; chapters are to recommend grading of candidates; junior members may now vote but not hold office; the last past president is a director; the board is authorized to make mutual agreements with other societies. Entrance fees are increased automatically $2 for each 500 members above 1000, the count to be made in December and fixed for a year. Apprehension that the fees would be so high as to keep out younger members gave way to the idea of increased service that could be rendered by the larger income.

Following an explanation of the similarity in work of the Engineering Institute of Canada with that of the Association, by Fraser S. Keith, secretary of the former, it was voted to leave the Canadian field to the Institute and to coöperate fully with it. Another indication along coöperative lines was a telegram from the Oregon Engineering Society asking for a proposal either to come into the association as a chapter or to make joint membership possible.

The next annual convention will be held in St. Louis. The result of the ballot letter for officers was as follows: President, F. H. Newell; vice presidents, W. W. DeBerard and F. A. Evans; new directors, W. W. K. Sparrow, P. E. Harroun, R. Burnham, F. D. Richards, A. A. Matthews and G. F. Collins.

Electrical Engineers Hold Their Annual Business Meeting

The American Institute of Electrical Engineers held its annual business meeting Friday evening, May 16, in the auditorium at the Engineering Societies Building, New York City. In the absence of the president, Comfort A. Adams, the vice president, W. B. Jackson, occupied the chair. He said that the year just ended had been full of accomplishment, but that the new one gave promise of being even more so.

The report of the Board of Directors for the year ended Apr. 30, 1919, was distributed at the meeting. Secretary F. L. Hutchinson announced the election of officers for the coming administration year as follows: President, Calvert Townley, assistant to the president of the Westinghouse Electric and Manufacturing Co. Vice presidents, C. E. Skinner, engineer of research division, Westinghouse Electric and Manufacturing Co.; John F. Fisken, chief engineer, Washington Water Power Co., Spokane, Wash.; N. A. Carle, chief engineer, Public Service Electric Co., Newark, N. J.; L. R. Jorgensen, electrical and hydraulic engineer, San Francisco, Calif.; Wills Maclachlan, inspector, Electrical Employees' Association, Toronto, Ont., and A. M. Schoen, chief engineer, S. E. Underwriters' Association, Atlanta, Ga. Managers, L. E. Imlay, superintendent, Niagara Falls Power Co., Niagara Falls, N. Y.; L. F. Morehouse, equipment engineer, American Telegraph and Telephone Co., New York City, and F. F. Fowle, consulting electrical engineer, Chicago, Ill. For treasurer, George A. Hamilton, Elizabeth, N. J., was reëlected.

The foregoing, together with the following holdover officers, will constitute the Board of Directors for the next administrative year: C. A. Adams, Cambridge; W. A. Del Mar, New York; G. Faccioli, Pittsfield; W. A. Hall, Lynn; E. H. Martindale, Cleveland; F. D. Newbury, Pittsburgh; E. W. Rice, Jr., Schenectady; Charles Robbins, Pittsburgh; Charles F. Ruffner, St. Louis; W. I. Slichter, New York; Wilfred Sykes, Pittsburgh. At the meeting of the Board of Directors F. L. Hutchinson was reëlected secretary for the coming administrative year.

President-elect Calvert Townley, in a brief address, said he considered it no time to make a speech, but that to decline to say a few words would be discourteous to the association which had honored him by making him president. He said the question of honor, however, was secondary, and an engineer was worthy of the name only in so far as he went ahead and did things. In the same way the

Institute must be constantly on the watch to find new means for service if it is to be worthy of the name of a national institution.

The Weaver memorial tablet, erected in acknowledgment of the services of William G. Weaver to the Institute, was unveiled, following an appreciation of Mr. Weaver's work by Dr. A. E. Kennelly. To Mr. Weaver, said Dr. Kennelly, was due much of the credit for the establishment of the great technical library now quartered in the Engineering Societies Building, and it was fitting that his portrait should form part of that library, for "Where a man's heart is, there should his head be also."

Mr. Weaver's talent for ferreting out and appraising electrotechnical literature amounts almost to genius, said the speaker. Whereas most men able to judge one type of technical literature have no ability for appraising other types, Mr. Weaver was skilled in evaluating all. His work as editor of the *Electrical World* established a high standard for electrotechnical literature. Mr. Weaver also has a remarkable talent for judging men. While most men are self-seekers, the speaker declared, Weaver is preëminently a seeker of others, and there are many men now leaders in the engineering world who owe their first success to him.

Edison Medal Presented to Benjamin G. Lamme

At the annual business meeting of the American Institute of Electrical Engineers held Friday evening, May 16, the Edison Medal was presented to Benjamin G. Lamme, chief engineer of the Westinghouse Electric and Manufacturing Co., for his invention and development of electrical machinery. The presentation ceremonies were taken part in by Dr. Carl Hering, chairman of the Edison Committee, who gave a brief history of the Edison Medal, and by B. A. Behrend, who related the achievements of Benjamin G. Lamme. The medal was presented by William B. Jackson, vice president of the American Institute of Electrical Engineers.

Dr. Carl Hering in his address told how the Edison Medal was founded upon the initiative of an organization known as the Edison Medal Association, composed of old associates and friends of Thomas A. Edison, who subscribed a trust fund for that purpose under an indenture dated Feb. 11, 1904, whereby the American Institute of Electrical Engineers agreed to award the medal annually.

By the terms of the deed of gift executed under date of Mar. 26, 1908, this gold medal is awarded each year to a resident of the United States or its dependencies or of the Dominion of Canada, "For Meritorious Achievement in Electrical Science, Electrical Engineering, or the Electrical Arts."

The award is made by a committee of the Institute consisting of 24 members, three of whom are appointed by the president each year, to serve for a term of five years, three elected by and from the Board of Directors each year, to serve for a term of two years, and the president, secretary and treasurer of the Institute ex officio.

The medal was designed by James Earle Frazer and bears on its obverse a portrait of Thomas A. Edison and on its reverse an allegorical conception, "The Genius of Electricity Crowned by Fame."

After telling what the medal was, Dr. Hering related the crowning achievement in the life of each of the recipients of the Edison Medal awards, who were: Elihu Thompson, 1909; Frank J. Sprague, 1910; George Westinghouse, 1911; William Stanley, 1912; Charles F. Brush, 1913; Alexander Graham Bell, 1914; Nikola Tesla, 1915, and John J. Carty, 1917.

In discussing Mr. Lamme's work B. A. Behrend said that the choice of the Medal Committee was especially fitting since Mr. Lamme had just completed thirty years of service in the electrical field. His work served as a bridge connecting the days when the science of electricity was in its incipiency with the present, in which it has become firmly established. Mr. Lamme's versatile personality has impressed itself on the engineering profession and is part and parcel of its development. His untiring labors are typical of the science which he has helped to build up. Mr. Behrend said that in his many-sided intellect as well as in name and even in personal appearance Mr. Lamme was likened to his predecessor in the electrical field, Benjamin Franklin.

The speaker told of Mr. Lamme being born in Springfield, Ohio, in 1864, and graduated from the Ohio State University as a mechanical engineer in 1888. He entered the testing department of the Westinghouse Electric and Manufacturing Company May 1, 1889. At that time the development of practically all types of polyphase alternating-current apparatus, railway generators and motors was a matter of the future, in which Mr. Lamme took a leading part. He invented and designed much of the apparatus and many of the systems and methods now in general use, and has taken out 153 patents, many of which are of fundamental importance and cover inventions that have contributed very largely to the present methods of generating, transmitting and using electrical power.

In 1900 Mr. Lamme was made assistant chief engineer of the Westinghouse Electric and Manufacturing Co., and since 1903 has been the chief engineer of this company. He is the author of many technical papers presented before engineering societies, some of which are regarded as classics. A paper on the Induction Motor, published 18 years ago, is used in many schools, and permission has recently been given for including it in the textbooks of the Naval Academy at Annapolis. His inventions and writings have made him well known among electrical engineers in Europe, as well as in America. In 1915 he was, upon nomination by the American Institute of Electrical Engineers, appointed by the Secretary of the Navy to membership on the Naval Consulting Board, and his services as a member of the board during the war were of great value to the country.

BENJAMIN G. LAMME

In response to the presentation speech by Vice President W. B. Jackson, Mr. Lamme said in part:

> Most people are particularly interested in accounts of wonderful inventions or discoveries; and the cold-blooded methods of the engineer in driving through all obstacles to a desired result do not contain for them any especial elements of romance or excitement. They do not recognize that the work of the engineer carries responsibilities, which ofttimes is not the case with the inventor; moreover, they are not aware that the engineer in the manufacturing field, when he once embarks on a project, is obliged to see it through to the end and that he must stand or fall by his results. To state it very briefly, the experimental attracts more attention than the analytical. The modern engineer, especially in the electrical field, is largely an analytical man and his adventures in analysis do not appeal to the popular taste.
>
> In an industrial organization the engineering developments are almost always the result of coöperation of many trained minds, and in consequence it is difficult to give any one man a large share of the credit. In such an organiza-

tion an individual may appear to have less opportunity to stand out prominently, in comparison with others, than where he is working more or less alone; yet it must be borne in mind that each engineer has the knowledge and experience of his coworkers upon which to build, and in this way he can accomplish results that would be impossible through his own individual capacity. Without the backing of immense resources in capital, equipment and experience, and without the greatest coöperation of many analytical minds, there could have been no such accomplishment as the modern high-speed, huge capacity turbo-generator sets. In such a development limitation after limitation, based upon previous experience, has been set aside. Each step in advance usually has offended some proven experience or practice. And, with each step, it usually was said, "This is the last," but the data from each one pointed a way to the next—and the end is not yet.

In progressive manufacturing organizations, as a rule, there can be no particular "pets." When any new line of development holds forth broader and greater possibilities, often the old and accepted practice and constructions are turned down ruthlessly in order to replace them with something more promising. Many times I have assisted strenuously in "obsoleting" some of my own best work just to make way for something of greater promise. For instance, I spent a number of my best years in doing my part in the development of the direct-current engine-type generator, up to a point where it seemed to be perfection, but I made equally great efforts in the development of the 25-cycle rotary converter which was destined to supplant, in general, the direct-current engine-type generator as a source of direct current; and still later I put equal efforts in forwarding the development of the 60-cycle rotary converter to supplant the 25-cycle machines. As a second instance of tearing down work in which I had a considerable share, I may cite the alternating-current engine-type generator, which had reached its greatest magnificence in the huge Interboro machines in New York City and which was rendered obsolete as a type by the development of the high-capacity turbo generator.

From the standpoint of development and inventions the past looms large, but how about the present and the future?

In looking over the past history of electrical engineering, the engineer may be inclined to think that the golden age of development and invention is past, and that the future contains no corresponding promise of new and startling things. But I do not agree that this is so. The pioneering period may be over, but the true development age has possibly just begun. The work is growing more difficult year by year, as our accumulation of knowledge grows. We are working ahead of our data, just as we did twenty to thirty years ago. Exactness and responsibility are required to a much greater degree than in the past, for our undertakings are greater in degree. The wonderful advances in the earlier times did not seem so very wonderful while we were in the midst of them. In fact, at the time, many of them were simply hasty remedies for serious difficulties, which were accepted and adopted out of necessity. But similar situations of today are also having their remedies supplied, ofttimes requiring vastly more difficult engineering than in the past; and viewed from a twenty-year future, many of these also will loom large. It is all because we have no proper perspective of the present. So the young engineer need not be discouraged. The fact that the work is growing more difficult year by year should be, in itself, a source of encouragement.

Mr. Lamme then told of his start in engineering thirty years ago, when upon leaving college he had entered the testing department of the Westinghouse company and had the good fortune to serve under the then shop superintendent, Albert Schmid. In those days electrical machinery was built by rule-of-thumb methods and Mr. Schmid, learning that young Lamme was good at calculations, had set him to checking and verifying certain curves and designs. This led to specifications for an improved double-reduction railway motor and later the development of a single-reduction gear motor embodying many radical features the main points of which may be found in the present street-railway motor.

Status of Large Turbines*

DURING the last two years there has been a marked increase in the number of large units in operation, particularly the horizontal single-shaft type of approximately 30,000 kw. capacity.

A consideration of the practical limit in size of single-shaft machines, so far as the questions of design enter into the problem, indicates that in general higher efficiencies at equal or less cost per kilowatt output can be obtained as the size of the unit is increased, particularly in capacities up to 30,000 kw.; and although one single unit of 45,000 kw. capacity is now in service, it cannot be assumed that the size of single-shaft units can be increased indefinitely.

From a manufacturing standpoint the limitation in size of a single-shaft unit is a limitation arising partly from materials at present available for blades and revolving elements and also from several inherent constructional difficulties which must be cleared away before further increases are fully justified.

In addition there is also involved the question of economic value of increased size of machines above 30,000 kw. If such factors as maximum efficiencies, cost per kilowatt and space requirements show a fairly uniform betterment as the size of the unit is increased, then neglecting the factors of design and operation, an increase in the capacity of the single unit will show a saving with increased system-load demand.

It would appear, however, that with the present constructional problems of prevailing frequencies and speeds and the recognized factors of safety, efficiency and cost, the size of systems today will hardly warrant units larger than 30,000 kw. capacity. In particular cases, and until increased reliability and improvements in operating efficiencies have been established, even larger systems will not justify the use of larger units.

The increasing size of prime movers and the increasing percentage which the individual turbo-generator unit bears to the total generating capacity of any system make the reliability of this type of machine a matter of much more importance from the operating standpoint than it was previously considered. While everyone appreciates the reduction in overhead charges due to the low investment cost per unit installed for these large machines, the low operating cost due to their increased efficiency and the low attendant labor and maintenance costs, yet operating companies must not forget for an instant that continuity of service is the bedrock of any central-station company's reputation and that the truly successful public-service company must give the community it serves the best and most reliable service possible.

With the increase in the size of the system and the recent increase in size of single units, an individual prime mover and generator often comprises 25 per cent. or more of the total generating capacity in many large companies, and the importance of these large units, as well as the necessity for their continuous operation, has increased proportionately. It is therefore becoming increasingly onerous on account of overhead charges to attempt to safeguard this capacity, and the reliable operation of the unit is absolutely essential to the satisfactory operation of the system.

Just how far it is safe to go in the installation of large generating units each company must of course decide for itself, but since units of over 20,000 kw. capacity are a rather recent development and since the service factor or ratio of hours available to total hours for some of these units is 90 per cent. or less, as compared with 97 to 99 per cent. for some of the older units, the importance of giving this matter careful consideration is plainly evident.

On the other hand, it must not be forgotten that certain of these large machines have records of continuous performance and output which surpass anything previously considered possible. For example, one of the 25,000-kw. units operated at 67 per cent. load factor during a 51-day run without shutdown; another machine of the same capacity has completed two 77-day runs at 67 per cent. load factor in the first instance and 70 per cent. in the second, while one of the 35,000-kw. units operated at 65 per cent. load factor for a 70-day run without shutdown.

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*Excerpts from report of Prime Movers Committee of National Electric Light Association.

TROUBLES WITH LARGE UNITS

In analyzing the causes of trouble as indicated by the operating records of the class of units of 20,000 kw. and over, there are several features of design that appear to be the most frequent sources of trouble. Labyrinth packings and thrust bearings have probably contributed to the major part of large-turbine operating difficulties. While these troubles in themselves have caused a considerable loss in operating time, they have also been responsible in a considerable number of instances for the development of far more serious troubles. Among these may be mentioned excessive vibration of parts, breaking of buckets and dangerous rubbing of stationary and moving elements, which in extreme cases have resulted in permanent deflection of shafts.

The most serious situation that has developed in the type and sizes of units under consideration, however, has been the number of quite recent turbine-wheel failures. In several instances these accidents have resulted in the complete wrecking of the units concerned. Such accidents, which are without parallel in the history of steam-turbine development, can hardly be considered as bearing directly on the question of performance of large-sized units, but rather as a factor to be considered in the improvement of design and construction of a specific type of unit.

The situation is now a critical one, and while any definite statement at this time would be premature, the committee wishes to indicate the necessity for early action both in safeguarding against further possible failures of machines now in operation and in definitely reaching solutions of those problems which involve important features of design and construction.

In general, however, the records of operating performances of these larger units, while too incomplete for definite conclusions, do indicate that there is every reason to expect as high a standard of performance for the recent types of large-capacity single-shaft units as had been obtained in the operation of machines of earlier design and smaller capacities. It is hardly overstating the case, however, to say that the records for reliability of operation of the larger units during the past two years have not been up to this standard.

While some of the difficulties may, without doubt, be directly concerned with operation, the greater percentage of trouble has been the direct result of shortcomings in details of design, materials or construction. On smaller-sized units, however, similar details of construction have proved to be much more reliable in their operation. It would seem that not only is the same degree of reliability of operation essential, but that a greater degree of reliability becomes more imperative with increasing sizes of machines and higher standards of service demanded by those industries dependent upon electric-power supply.

DISCUSSION

W. L. Abbott, Chief Engineer, Commonwealth Edison Co., Chicago, Ill.: In substance Mr. Abbott had the following to say relative to turbines. The performance of large turbines during the last two years has been of great concern, particularly turbines of 20,000-kw. capacity and over. So much has it interested engineers that it is the subject of study by another organization, which he did not name, but whose report he expects to be forthcoming within a few months. Although a number of failures have occurred in large machines, nothing in the situation warrants distrust of the large units of the particular design which has developed trouble, the trouble by the way being due to a number of faults which were incidental. These faults are now in the way of being corrected.

Relative to the ratio of the largest unit to the total station capacity installed, Mr. Abbott pointed out that this ranged from 7 to 100 per cent. Units as large as 33 or even 50 per cent. of the station capacity may with confidence be contemplated. The mechanical troubles to which these units have been subjected will be overcome, and we may gradually rely on units of proportionately larger size, compared with the total station capacity, than we have been using in the past.

H. M. Cushing, Engineer, Buffalo General Electric Co.: Mr. Cushing stated that the nature of their load was such that no long runs of any of the units, which by the way are of 20,000-kw. capacity, are necessary. One or more units are shut down every night, and it is seldom that any one unit makes a continuous run of two or three days. These machines have been giving a service factor of 89½ per cent., operating under a total steam temperature of 650 to 700 deg.

W. B. Finley, Superintendent of Motive Power, Interborough Rapid Transit Co., New York City: Mr. Finley urged that the committee standardize its form of report so that comparison might be facilitated. In discussing experience with the operation of three 30,000- and one 60,000-kw. reaction turbine in the Seventy-Fourth Street Station of his company he pointed out that the Fifty-Ninth Street Station, which is of 205,000-kw. capacity, and the Seventy-Fourth Street Station, which is of 195,000-kw. capacity, were operated in parallel, the machines being operated so that there was available for either station about 15,000 kw., or half the capacity of any one of the three machines. The 30,000-kw. unit is the basic unit used by this company, and Mr. Finley pointed out that it was a comparatively small unit, considering the total station capacity.

Mr. Finley urged a standardization of turbine performance, saying that they worked out such a system of standardization for use by the Interborough Rapid Transit Co. When the large units were first installed by this company there was no sense of security, but this, however, has been replaced by the strongest sense of security, which is accounted for by the satisfactory performance of all of the units. The 60,000-kw. machine is operated six days a week, being shut down on the seventh for inspection. When the 30,000 units were first put in operation, piping supports were used, which, when the turbine heated, tended to distort the piping, the distortion being magnified by the time it reached the turbine, causing the dummies to run. The trouble has been overcome and the shutdown period greatly lengthened. Mr. Finley is confident that the troubles that have developed in the 30,000 single-shaft units in the Fifty-Ninth Street power house will be overcome.

Philip Torchio, New York Edison Co.: The limit in capacity of a single-shaft turbine is not 45,000 kw., at least theoretically, says Mr. Torchio, and he deems it unwise at this time to place any limit to the capacity that may be developed by this type of machine. He thinks that with this type the chief question is one of speed, and that for the speed used we may have exceeded the capacity of the unit; that is, by decreasing the speed somewhat, the larger wheels might be able to operate satisfactorily.

Mr. Torchio advised that the Power Station Committee of the American Institute of Electrical Engineers had secured the coöperation of large turbine builders to prepare papers on turbine design, and it was expected that these papers would be ready for presentation at the October meeting of that institute.

Oscar Junggren, Engineer, Turbine Department, General Electric Co., Schenectady, N. Y.: Mr. Junggren said that he could not add anything to the statement already made and printed by the General Electric Co. (This statement is included in the committee's report.)

The company, he said, had the same difficulties which everyone had encountered during the war. There was great difficulty in securing suitable materials, and the difficulty extended to the engineering, drafting and shop forces. Another factor contributing to the bad state of affairs was the large building program which the company undertook for the Navy and the Emergency Fleet Corporation. The turbine business of the company, he said, had almost doubled. He pointed out that the company had already completed destroyer turbines which will not see their hulls for two years. He stated that the company is under no apprehension that it cannot carry out its obligations as related to its turbine business.

E. H. Sniffen, Manager Power Section, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn.: The problems embraced within the design and operation of steam turbines are as important as any the industry faces.

Since eighteen or nineteen years ago engineering enterprise involved in design has been left to the manufacturers themselves. Mr. Sniffen hopes and is of the opinion that we will see greater cooperation between builders and manufacturers. He believes that it is well that the various designs have been evolved and tried out. He would like to see more standardization and cooperation of thought, as in the electrical end of the industry. There should not be such diversity of opinion between manufacturers and engineers, as the satisfactory operation of a turbine depends upon details of design.

N. E. L. A. Annual Convention

NATIONAL Electric Light Association held its 42nd annual convention at the Million-Dollar Pier, Atlantic City, N. J., May 19 to 22, 1919. This year's convention proved to be one of the most successful that the association has ever held; a total of about 2500 members and guests registered. This year's exhibits were greater and better than at past conventions, the 85 exhibitors taking a total of 50,000 sq.ft. of space, or twice that of any previous year. In all a total of 18 technical and business sessions were held on Tuesday, Wednesday and Thursday. The keynote of the convention was service and constructive coöperation.

The first meeting, a general and executive session, President W. F. Wells occupying the chair, was held on Tuesday morning. Mr. Wells spoke of the cordial welcome that has always been given the association by Atlantic City, and introduced the mayor, Honorable Harry Bacharach, who said in part that "Atlantic City does not want as residents men who are not 100 per cent. American citizens. Neither does it want any conventions save those whose membership represents the same type of Americanism." He told how Atlantic City went over the top in all the patriotic drives and how it took care of the dependents of its men in the service. After his address the Mayor presented the association with the key to Atlantic City.

MR. WELLS' PRESIDENTIAL ADDRESS

Following Mayor Bacharach, W. F. Wells made his presidential address in which he laid stress upon the problems that the utilities have to contend with today, such as fair treatment of employees, satisfying customers, high costs, the Bolshevik movement, Government ownership, etc. Mr. Wells said in part: "As we were able during the war to meet and solve the unforeseen problems presented, so we will now go forth in the same spirit and cope with those that are to come. From now on, our particular duty is to the people. Our duty to that part of the people who are our customers is to render them satisfactory service. Our duty to those who are our employees is to maintain loyalty by fair treatment. To those who own our securities, it is to maintain the integrity of their investments. Our duty to the others of the commonwealth under whose rules and regulations we operate is to furnish convincing information that we are giving them a better service for less money than can be obtaind in any other way."

During his address Mr. Wells said regarding the higher scale of prices of nearly everything that enters into electric light and power service: "These specific problems are all factors of one fundamental, psychological equation, to wit: 'The revenue from contented customers shall equal a satisfactory return for labor and capital.' For notwithstanding the physical and financial factors, the important factors in the fundamental equation, are psychological. The revenue from contented customers must equal the satisfactory return for capital and labor. Our problem, therefore, of keeping our customers contented with our service and maintaining their good will is largely a matter of psychology. Good will, though unrecognized by the courts in rate cases, is one of our most valuable assets and depends upon the manner in which we come in contact with the public. Money, although very important, is only one of the factors of a satisfactory return for one's service. The college professor is often better satisfied with his stipend than a broker with five times the income."

In regard to regulation and inspection of utilities the speaker expressed the opinion that, "If our customers, employees and investors are satisfied, there is little danger that any political demagogue will endeavor to favor one at the expense of either of the others." He said that we should not overlook the Bolshevik movement and urged that the members of the association take into immediate consideration this question in order that definite steps may be taken to consider this matter seriously in coöperation with other national bodies in this country.

In regard to municipal ownership or administration Mr. Wells expressed the belief that it was economically unsound and said: "We can use as examples of the results of public ownership the railroads, the merchant marine, the express, telegraph and telephone companies, which under present Government administration have not only increased rates for a service much inferior to that furnished in the past, but which on account of continuously increasing operating cost may still further increase the rates to the public."

Acting Secretary S. A. Sewall read a report of the work of the association during the year, and was followed by W. H. Blood, who read his report as insurance expert for the members of the association. This report was printed and distributed at the meeting. It not only deals with the activities of the insurance expert as an adviser and expert witness for the member companies in legal suit brought against them in cases of fire assumed to be of electrical origin, but also deals with his work on the revision of the National Electrical Code.

REPORT OF RATE RESEARCH COMMITTEE

Alex. Dow presented the report of the Rate Research Committee, of which he is chairman.

Much discussion followed the presentation of this report. It combined in part with the discussion of the progress report presented by R. J. McClelland, chairman of the special joint committee on Determination of Power Factor in Polyphase Unbalanced Circuits.

In regard to the power factor of customers' circuits Mr. Dow expressed the opinion that the small customers were most difficult to deal with; that with a customer using 300 hp. and over it was a comparatively easy matter to make them see the advantage of maintaining high power factor. The matter of penalizing the customer for low power factor, although justified, was a problem difficult of solution; and to anyone considering it he would advise giving the matter most serious consideration before putting the project into effect. The point was brought out that it was not the large motors, in general, on the system that caused low power factor but a multiplicity of small partly loaded machines.

It was brought out in the discussion that it had been found by investigation carried on in Italy that a reactive kilovolt-ampere cost about one-third to produce what it did to produce a kilowatt of energy. Of course this would very somewhat with the type of plant, location, etc. A suggestion was made, and one that seemed to meet with favor, that the reactive kilovolt-amperes and kilowatts should be metered separately and the customer billed for both. This would give the user of the power an opportunity to practically eliminate the kilovolt-ampere bill entirely if he would maintain the power factor of his electrical system at a high value.

Tuesday afternoon five sessions were held: First accounting session, first commercial session, first electrical-vehicle session, first and second technical hydro-electric sessions. At the first technical and hydro-electric session the report of the Committee on Prime Movers was presented by the chairman of the committee, N. A. Carle. The discussion on the steam turbine part of this report is published elsewhere in this issue.

SECOND TECHNICAL AND HYDRO-ELECTRIC SESSION

The second technical and hydro-electric session was held in the Belvedere, eleventh floor, of the Hotel Traymore. At this session E. B. Meyer, chairman of the Committee on Underground Construction and Electrolysis, presented the report of the committee. It was evident from the report and the discussion that followed that there is a tendency to standardize the important elements in underground construction. There appeared to be considerable objection to the use of paraffin as a joint filler, due to shrinkage.

The report of the Committee on Overhead Lines and Inductive Interference was presented by A. E. Silver, chairman of the committee. The part of the problem that the greatest interest was shown in was the relations with the telephone companies. There appeared to be a well-defined opinion among the members that the power company should coöperate in dealing with the telephone companies in the interest of fairness to all.

At the close of the session W. C. L. Eglin, chairman of the Committee on Safety Rules and Accident Prevention, announced that the National Electrical Safety Code was to come up for discussion at the meeting on Thursday morning and he hoped the member companies would offer constructive suggestions for formulating a code that would be satisfying to all parties interested. The speaker paid high tribute to the Bureau of Standards and its work toward formulating a satisfactory safety code and said that there had been much misunderstanding regarding this code. He made it clear that he wanted to go on record as in favor of the code, that the code was here to stay and that the proper thing to do was for all interested parties to get together and formulate a code that is workable and that will make electrical construction safe without imposing any hardships upon the operating companies.

Professor C. F. Scott, Yale University, expressed himself as being gratified with the spirit of constructive coöperation shown by all those taking part in the meeting and compared this with conditions existing a few years ago, when every interest was for itself.

An audience that filled the Rose Room of the Hotel Traymore to standing capacity attended the second general and executive session, held on Tuesday evening. The reports of the Public Policy Committee and the National Committee on Gas and Electric Service were presented, followed by addresses on the sales of utility securities to customers and on socialism.

THIRD GENERAL AND EXECUTIVE SESSION

On Wednesday morning the third general and executive session was held. One of the principal features was an address, "Planning for Power," by George Otis Smith, Director of the Geological Survey, Department of the Interior, in which he described the needs of this country for additional electric-power facilities. In regard to Secretary of the Interior Lane's proposed superpower system, the speaker said: "The picture of the super-power system demanded by the rapid growth of this industrial region [referring to the northeastern part of the country] includes a multiple transmission line of high voltage with its thousands of steel towers extending from Boston through our Eastern States, crossing the Connecticut near Springfield, the Hudson at Poughkeepsie, the Delaware near Easton, and the Susquehanna below York, and so on to Washington and Richmond. Into this unified system large-unit, steam-electric stations at tidewater and near the mine mouths and hydro-electric stations at old and new sites would deliver energy as required, and from this great power main would flow the energy to serve millions of homes, a score of railroads, hundreds of public service companies, and thousands of manufacturing plants.

Referring to the importance of cheap power, the speaker said: "Our interest as citizens in these plans for cheaper energy is far more than a commercial interest. The organization of the nation's business to obtain the lowest costs is distinctly a matter of public service, in which corporation and Government bureaus may well join efforts. Tomorrow prosperity must mean profit-sharing on a thorough-going scale, in which we shall all receive in proportion as we have served. So the industrial program which emphasizes mechanical power is the most effective assurance of better conditions for all who work in this busy world of ours."

A more complete abstract of Mr. Smith's address will appear in an early issue.

Six sessions were held Wednesday afternoon: Second accounting, second commercial, third commercial, second electric-vehicle, third technical and hydro-electric and fourth commercial.

A discussion on "Effects of the War in Isolated Plant Cost," at the third commercial session brought out the facts that previous to the war the isolated plant could produce power cheaper than the central station. However, due to the increased cost of everything that goes into the production of power, the power-cost curves of the two types of plants have crossed, and now it is possible for the central station to produce power cheaper than many of the isolated plants that could show a lower cost figure previous to the war. It was necessary before the war for the central station to sell power at a reduced price in order to meet the isolated-plant figure. This practice was considered bad business, and even now when the central station can in many cases produce power cheaper than the isolated plant, it would be poor policy to sell at the reduced rates inasmuch as the customer should be willing to pay something for the convenience of being relieved of responsibility of operating a power plant. It was recommended that an endeavor should be made to sell power on the merits of greater convenience to the owner of a manufacturing establishment rather than to try to meet the price at which the power could be generated in an isolated plant.

POWER FACTOR IN CUSTOMERS' INSTALLATIONS

Another important discussion at this session was "Power Factor in Customers' Installations." This subject was profitably discussed from several angles. Suggestions as to how the meaning of power factor might best be explained to the customer were offered by R. H. Tillman and Prof. C. F. Scott. Robert Treat, in discussing power-factor corrective apparatus, told of the increasing use of synchronous motors and stated that such motors as now constructed are suitable for any requirements for which an induction motor is ordinarily used save where variable speed is required; they are to be found driving air compressors, pumps, blowers, etc. With a synchronous motor one pays for corrective capacity at about one-third the ordinary cost for power with an induction motor. Comparing with the synchronous condenser, static condensers and phase advancers, Mr. Treat pointed out that with a synchronous motor the losses were less than with an induction motor with a condenser for the same corrective value. The synchronous condenser is more flexible than a static condenser although the latter is more flexible for small powers. The phase advancer compares favorably with the synchronous motor, but as its production has not yet been put on a quantity basis, it is at present more expensive. Moreover, it can be used only with an induction motor having a phase-wound rotor.

A paper by R. H. Gardner on a result of low power factor was then read by Mr. Mitchell. The author emphasized that the loss in efficiency at low power factor justifies special efforts on the part of the consumer to keep the motors loaded. Furthermore, low power factor necessitates the operation of more generating apparatus to maintain a given load. It was suggested in the discussion that a bonus to customers for high power factor would compensate for the extra investment in corrective apparatus.

The last phase of this subject to be taken up was the effect of electric furnaces, brass furnaces and welding machines on the power factor. The electric furnaces have, as a rule, high power factor although this is affected by the frequency, voltage and load. With electric welding it is customary to introduce a motor generator set where the service is alternating, but where the alternating current is used for the welding, a very low power factor results—25 to 35 per cent.

At the third technical and hydro-electric session the reports of the Committee on Electrical Apparatus and the Committee on Meters were presented and discussed. The former report deals with generators, switchboards, transformers, substations, power-factor correction and apparatus for special industrial fields. The printed report contains 108 pages. The discussion brought out considerable difference of opinion regarding standardizing transformer polarity, it being the opinion of some that subtractive polarity should not be adopted for distribution transformers, while others supported the committee's report for such standardization. On a motion the subject of polarity was referred back to the subcommittee for further consideration.

The subject of extinguishing fires in generators created considerable interest, the use of steam or water or both being advocated for this purpose, although preference was shown for the latter. It was pointed out that immersion of the armature coils in water if not prolonged would not permanently injure them provided they were dried out soon after. Abstracts from this report will appear in early issue of *Power*.

At the fourth general and executive session, held Thursday morning, the report of the National Nominating Committee was presented, which announced the election of the following national officers: President, R. H. Ballard, Southern Calif. Edison Co.; first vice president, Martin J. Insull, Middle West Utilities Co.; second vice president, M. R. Bump; third vice president, Frank W. Smith, United Electric Light and Power Co., New York; fourth vice president, Walter H. Johnson, Philadelphia Electric Co.; treasurer, H. C. Abell, American Light and Traction Co. Members of the executive committee to serve three years: W. H. Atkins, Edison Electric Illuminating Co., Boston; P. G. Gossler, A. B. Leach & Co., New York; D. H. McDougall, Toronto Power Co., Ltd.; member of executive committee to serve two years, R. J. McClelland, Electric Bond and Share Co. The secretary was instructed to cast one ballot for the nominees, and they were declared duly elected.

Award of John Fritz Medal to General Goethals

In recognition of his distinction in the engineering profession and as the builder of the Panama Canal, Major General George Goethals has been awarded the John Fritz Medal. The presentation of the gold medal, with an engraved certificate stating the origin of the medal and the specific distinction, was made by Ambrose Swasey, past president of the American Society of Mechanical Engineers, in presence of a large and appreciative assemblage of engineers and guests in the auditorium of the Engineering Societies Building, 29 West 39th St., New York City, on Thursday evening, May 22.

Addresses were made also by Henry L. Stimson, former Secretary of War, and W. L. Saunders, past president American Institute of Mining and Metallurgical Engineers, testifying to the perseverance, skill, singleness of purpose and devotion to duty by which General Goethals has brought to successful completion one of the greatest works of the ages and placed him on the list of men whose engineering achievements are known the world over.

Mr. Swasey in his address said General Goethals had gone to war with the element when his country was at peace, and had truly represented himself in the ten years' fight on the canal job as a soldier, engineer and man.

In responding the General said several other men came to his mind in accepting the medallion, chief among them being the late Colonel Roosevelt, whose courage and steadfastness as the chief executive of the nation made the canal possible. General Goethals recalled how the medical men of the army conquered the yellow fever scourge only after several of the best among them died and others were left permanent cripples for their sacrifices, which he compared to any that had occurred in the world war. In concluding he paid a tribute to the 50,000 American workmen who did their part, imbued solely with the idea that their efforts meant the future glorification of the country's greatness.

The John Fritz Medal was established in 1902 in honor of John Fritz, of Bethlehem, Penn. The medal is of gold, is awarded not oftener than once a year and is accompanied with the engraved certificate. This certificate states the origin of the medal, the specific achievement for which the award is made, and bears the names of the members of the Board by which the medal was awarded and the signatures of the president and secretary of the board. The Board of Award is formed of sixteen men, four representatives from each of the four National Societies of Civil, Mining, Mechanical and Electrical Engineers. The first award of the medal was made to John Fritz at a dinner given to him on his 80th birthday, Aug. 21, 1902. Among those who have received the medal in past years are George Westinghouse, Alexander Graham Bell, Thomas A. Edison, Charles T. Porter and Prof. John E. Sweet.

Seizures of Diesel-Engine Pistons*

By Edward Ingham

One of the principal troubles in the working of Diesel engines is seizure of the piston. When it is remembered how small is the clearance between the piston and the cylinder liner in such engines, it is rather surprising that cases of seizure are not far more frequent.

In a Diesel engine, small piston clearances are essential if a high efficiency and smooth running are to be obtained. The designer is confronted with the problem of reducing the clearance between the piston and the cylinder liner to the smallest practical limits, without at the same time involving undue risk of seizure of the piston.

When seizure takes place the results may easily prove disastrous; thus, if the motion of the piston is suddenly arrested, the energy stored in the flywheel tends to keep the crankshaft rotating, so that the crank exerts a severe pull on the connecting-rod, with the result that the connecting-rod or crosshead bolts are severely strained. Should the bolts fail, the consequences may be easily imagined. In one instance where seizure of the piston caused failure of the crosshead bolts after elongating them and reducing their diameter from 1 in. to $\frac{5}{8}$ in., the connecting-rod was badly bent, and fracture of the piston and the cylinder liner resulted. One of the nuts from the broken bolts dropped and fouled the crankshaft and the engine frame, and as a consequence, a piece of metal was broken out of the frame, while the crankshaft, which had four double-sweep cranks, was twisted evenly throughout its entire length, the angle between the first and the last cranks being about 15 degrees.

It may be said that seizures of Diesel-engine pistons are mostly caused by overheating of the piston and the expansion of the metal which results. As already pointed out, the clearance between the piston and the cylinder liner must be extremely small. If a piston expands much more than the liner, the small clearance is reduced to such an extent that the piston cannot move freely, and seizure is the consequence.

The tendency to seizure is aggravated by the fact that in the ordinary trunk-piston engine, where the piston is attached directly to the connecting-rod, the forces imposed on the piston do not act in the direction of the axis of the cylinder. Owing to the obliquity of the connecting-rod, a more or less severe side pressure is exerted on the cylinder walls, so that the motion of the piston is not as uniform and free as it otherwise would be.

Clearly, if the trouble under consideration is to be obviated, it is of fundamental importance that the temperature of the piston be prevented from rising too high. Hence, the question of lubrication must receive the most careful attention. Not only the piston and the liner surfaces, but the piston pin and the top bearing of the connecting-rod must be efficiently and continuously lubricated. With the horizontal type of engine, lubrication of the piston and the

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*Abstract of an article in *Electrical Review*, London.

liner surfaces can be effected satisfactorily by a single feed on the upper side, since gravitation assists in distributing the lubricant; but with engines of the vertical type the lubricant must be supplied through a number of feeds if a thorough distribution is to be effected.

Lubrication of the piston pin and the top end bearing is effected in different ways. Special care should be taken to insure that the pin will be thoroughly lubricated at starting times. When an engine is shut down, the heat radiated by the piston, pin, etc., has a tendency to burn up the lubricant in the top end bearing, so that when the engine is again started, the lubrication of the bearing may be deficient. Overheating of the pin and the piston may then result, involving considerable risk of seizure. The majority of piston seizures appear to have been brought about in this way.

With the object of preventing overheating, some pistons are cooled by water or oil, and this is an effective method of reducing the risk of seizure, provided the circulation of the liquid is maintained.

The design of the piston must be such that the liability to distortion will be reduced to the minimum, since a very slight amount of distortion may lead to seizure. The design must also be such that expansion will take place uniformly all around the piston. There should be a good body of metal, as this will assist in the escape of the heat transmitted to the piston. Special attention should be given to the question of avoiding initial strain during casting, which might lead eventually to fracture. A fracture in a diametrical direction would be especially liable to cause a seizure. Diesel engines are of the trunk-piston type, but at least one manufacturer has introduced a crosshead type of engine. This type of engine is far less liable to piston seizures than the ordinary type. The provision of a crosshead, slides and piston rod results in the piston's moving truly and freely in the direction of the axis of the cylinder, so that side thrusts are obviated. For this reason alone, the crosshead type of engine is an improvement over the trunk type, but there are other reasons. The connecting-rod top end bearing, instead of being in the cylinder, where the heat is intense, is well away from the cylinder; hence there is less liability for the bearing and the piston to become overheated. Further, the engine is provided with forced lubrication, so that every bearing is continuously flooded with oil. A small hand pump, fitted in connection with the lubricating system, enables all the pipes and bearings to be primed with oil just before starting up, and in this way all bearings are copiously supplied with the lubricant from the commencement of the running.

Many piston seizures are to be attributed to the use of cooling water containing lime and magnesium salts. When there is a large quantity of these in solution in the water, the salts are liable to become deposited in the narrow water spaces, involving risk of overheating and fracture. The practice of allowing water to circulate for some time after the engine has been shut down will tend to prevent the deposition of the solid matter, which is mainly due to the increase in the temperature of the stationary water which takes place when the engine is stopped and the heat in the metal walls is transmitted to the water.

The Present Condition of Belgian Industries*

Information supplied by the Comité Central Industriel de Belgique, regarding the destruction of property in Belgium by actual warfare or with the deliberate intention of crippling the country's industries shows innumerable cases of the destruction of industries. Sights such as those at La Louviere, at Charleroi, at Seraing, leave no doubt as to the industrial losses which Belgium suffered in the war. Some industries, however, have been spared. The interests of the invaders themselves induced them to respect to a certain extent the food industries (mills, sugar refineries, breweries, etc.), the public utilities (gas works, power houses and water works) and the coal mines. Other enterprises were taken possession of and exploited to the profit of the enemy in spite of resistance by their owners and the workmen.

All these industries have, in the main, preserved their equipment and will be able to render valuable assistance in the work of economic reconstruction provided they receive the necessary support.

In their hasty retreat the Germans abandoned quantities of all sorts of products, which, if rationally distributed under the system which is now being organized, may serve as a starting point for future manufacturing activities.

As to the labor situation, it must be pointed out that the working portion of the population was not diminished to anywhere near the extent it was in the great belligerent countries. The fact that compulsory military service was instituted in Belgium only three years before the war and the impossibility of carrrying out conscription levies because of the rapidity of the German occupation of the country resulted in the majority of the men of military age remaining in Belgium. Many of the laboring class have suffered from privations which have temporarily undermined their health, and nearly all of them have been exposed for a long or short time, to the demoralizing influence of enforced idleness. But, in general, the working population is still there, with its hereditary qualities, which training will rapidly revive. It is ready to return to work.

Latches on Fire Doors

The importance of being able to close securely all fire doors of boilers cannot be overestimated. According to *The Ausable News*, several severe accidents have occurred at one of the plants of the Consumers Power Company of Michigan, due to the fire doors being blown open as a result of a boiler tube explosion. The fire blown out of the furnace burned the men so severely that in one case a fatality resulted. As a result of these accidents the company has issued the following rules:

All fire doors must be equipped with a form of latch that will prevent the doors from opening in case of an internal explosion.

Safety representative and boiler room foremen must see that these latches are kept in operating condition at all times. It should be seen further that the fire doors are in a condition that they can be closed easily so that the purpose of having latches will not be defeated due to not being able to close the furnace doors in the first place.

All stoker operators and all others who have occasion to open a furnace door on an operating boiler must securely latch the fire door before leaving it.

An improperly operated boiler is as dangerous as dynamite.

Keep the safety valves well oiled.

When blowing off boilers open and close the blowoff valves slowly.

All steam traps should be kept clean and in working order. Traps are the only safe means of removing water from the line. Should a trap get out of order and it be impossible to repair it at once, the bypass should be opened sufficiently to pass all water that might collect.

Open each door to the boiler at least once a day and inspect carefully for leaks at all points.

Keep your hand on the stair-rail. Boiler-room stairs are often steep and sometimes are narrow and difficult.

Before entering any boiler, notify the responsible person of your intention.—N. E. L. A. *Bulletin.*

In discussing the paper on lubrication, read before the Physical Society by Principal S. Skinner, C. T. Thomsen said that it had been found that among mineral oils the best lubricants were those with a large proportion of unsaturated hydrocarbons. It is thought that the more of these that are present the more intimately the oil will adhere to a metallic surface. Now, some of the animal and vegetable oils are very largely composed of unsaturated constituents, so that this property of adherence to metallic surfaces may readily be greater in these cases. He thought compressibility was of negligible importance.—*The Engineer.*

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*From a report by Trade Commissioner H. T. Collings, Brussels.

Salt Instead of Water Used in Ammonia Absorber

In describing the Seay ammonia absorption refrigerating plant to the Liverpool Engineering Society, B. Rathmell said that it had been proved capable of making 25 tons of ice per ton of coal burned, with an estimated evaporation of 9 lb. of steam per pound of coal. In this system of refrigeration the absorbing medium used is ammonium nitrate, normally a crystalline salt. In absorbing ammonia it changes into a sticky viscous liquid form. It is stated that 3 lb. of this salt absorbs 1 lb. of pure ammonia. Thus, in the absorber the salt takes up ammonia gas, as it comes from the refrigerator or ice-making tank at low pressure and temperature, the crystalline salt changing into thick liquid form. In the generator this liquid is heated by steam coils until the ammonia is driven off again into an ammonia condenser of any ordinary type; the salt reverting to its solid form in the process.

In connection with the generator it is claimed that much economy in heating is obtainable over what can be secured in the older water and ammonia absorption plant. This is because the change of state of the salt from liquid to solid form liberates its latent heat of liquefaction, which goes toward the heat required for vaporizing ammonia; and thus of the approximately 520 B.t.u. required to vaporize each pound of ammonia, only about 200 B.t.u. have to be provided by the steam-heating coils.—*The Engineer*.

France's Electrical Bill Against Germany

According to the *Electrical Review*, London, M. Dubois recently submitted to the French Chamber of Deputies a report on behalf of the Budget Commission, in connection with the bill dealing with the reparation of damages caused by the enemy during the war. The report discusses in detail the extent of the damage to various industries.

In the case of electrical and mechanical engineering works, which represented a total working capital of $400,000,000 in 1914, the works have been destroyed in the proportion of 90 per cent. The machinery and plants were worth $94,000,000, and as prices have almost trebled in the meantime the loss under this heading amounts to $253,800,000. The raw materials and manufactured products which were removed or destroyed are stated to represent a present value of $270,000,000. It is estimated that the losses to productive labor due to six years of enforced stoppage, amount to $171,000,000 while the damages to buildings are computed at a further sum of $84,000,000. Dealing with the electric supply works, the report states that 80 per cent. of the machinery and plant, which was valued at $30,000,000, has been destroyed, and, as cost prices have risen about threefold, the loss amounts to $72,000,000. It is calculated that the losses on the working capital of $39,600,000, due to the stoppage of French labor, amount to $28,600,000, while the damage to buildings is placed at $12,600,000.

Water Power Development in France

In view of the future high cost of coal, in France, the Minister of Public Works has nominated a committee to study the most scientific methods of utilizing the country's water power on the largest scale. A further departure considered is that of erecting hydraulic laboratories, fully equipped for the investigation of turbines and other water machinery under ordinary working conditions; the erection of standardizing stations for machinery employed in the hydro-electric industry, and testing stations for such machinery.

The Technical Institute of Toulouse has gone ahead of this projected departure by planning an installation estimated to cost between 1,500,000 and 2,000,000 francs, to demonstrate practically the best conditions of working high-, medium-, and low-head waterfalls, as well as water-gaging station, with special regard to the circumstances of the region of the Pyrenees. The government has recognized the value of such individual efforts, and deemed it well to encourage them by financial help. In response to the request of the Minister of Public Works last year, the government voted 440,000 francs in aid of private hydraulic laboratories, nearly half of which has already been allotted to the Toulouse Institute. A supplementary vote of 250,000 francs has since been asked for to help the scheme for the erection at Grenoble of an electrochemical and electrometallurgical institute. The third of the existing institutes—that of Nancy—is concentrating its attenton on the use and improvement of electric motors. — *London Electrical Review*.

New Publications

INDUSTRIAL GOODWILL. By John R. Commons, of the University of Wisconsin. Published by the McGraw-Hill Book Co., New York City. Cloth; 6 x 8½ in.; 213 pages.

One gets an idea of the contents of the book from the following list of subjects touched upon: Commodity, machinery, goodwill, the public, democracy, solidarity, theory and practice, security, labor market, insurance, health, the shop, education, loyalty, personality, depression, the world. In brief the book is an argument for the engineering theory of labor by an author who has written much on labor problems.

FUNDAMENTAL ELECTRICITY. By W. P. Wieman, Member Society Astronomers De France. Published by the Wieman Co., N. S., Pittsburgh, Penn., 1919. Cloth; 4½ x 6 in.; 127 pages; 27 illustrations.

In this little book the author attempts to explain what electricity really is by astronomical phenomena. The sun is assumed to be a permanent magnet with its field passing through the earth and the other planets so as to give them a North and South magnetic pole similar to that of the earth.

It is claimed that an electromotive force is not generated by a conductor cutting lines of magnetic force, but by the increase and decrease in quantity of magnetic lines through a closed circuit or loop. Although this little book cannot be called a treatise on fundamental principles of electricity, in the general sense of the word, nevertheless the speculative treatment of the subject makes it interesting reading.

INDUSTRIAL ELECTRICAL MEASURING INSTRUMENTS. By Kenelm Edgcumbe, M. Inst. C. E., M. I. E. E. Published by D. Van Nostrand Co., New York, 1918. Cloth; 5½ x 8 in.; 414 pages; 260 illustrations. Price, $5.

This book treats the general subject of electrical measuring instruments, especially the principles of operation. Only elementary mathematics has been employed and then to only a very limited degree. It has been the endeavor of the author to present this subject so that the reader can obtain a clear mental picture of what is going on in the various devices.

This is the second edition and has been revised and enlarged. The expansion of all sections has been such that in order to keep within reasonable limits the author has omitted the subject "fault localization" as distinguished from "fault detection," as he has also "relays" and "overpressure devices." On the other hand, "Pyrometers" have been dealt with at some length. The sections that have been especially enlarged are those dealing with Constructional Details, Power Measurements, Induction Instruments, Current and Pressure Transformers and Graphic Instruments.

Although the author is British and naturally has treated the subject from this point of view, nevertheless, there is in the book an abundance of information that applies equally well to American practice, thus making it of value to those interested in electrical work in this country.

Personals

Julius Alsberg, consulting engineer, Chicago, announces the removal of his offices from the Tribune Building to the Marquette Building, 140 South Dearborn St.

Roland B. Page has been appointed eastern district manager for Lea-Courtenay Co., with offices at 810 Broad Exchange Building, Broad and Franklin Sts., Boston, Mass.

F. X. Meehan, who has been connected with Fairbanks Morse & Co. for the last six years, has been appointed advertising manager of the Walter A. Zelnicker Supply Co., St. Louis, Mo.

J. P. Alexander has returned to New York City with the power and mining department of the General Electric Co., 120 Broadway. Mr. Alexander has represented the company for some years in central New Jersey, with headquarters at Trenton.

George D. B. Van Tassel has been appointed Detroit district sales agent of the Power Specialty Co., operating in the territory of eastern and southern Michigan and western Ohio. His office will be in the Dime Bank Building. Mr. Van Tassel has heretofore been sales engineer of the company's Chicago office.

Charles H. Stoddard has been appointed consulting marine engineer of the Heine Safety Boiler Co., St. Louis, Mo. Mr. Stoddard has held many important positions, such as chief engineer of the Fulton Iron Works and of the Risdon Iron Works of San Francisco, civilian superintendent of shops at Mare Island Navy Yard, and more recently chief engineer of Moore & Scott Iron Works.

Irving E. Brooke, recently with the Pensacola Shipbuilding Co. as assistant to the naval architect and formerly electrical engineer with the Arnold Co., has opened an office as consulting engineer at 807 Stock Exchange Building, Chicago, for the practice of general engineering work. Mr. Brooke was formerly in charge of mechanical work in the city engineer's office, and prior to this was on the engineering staff of the Commonwealth Edison Co. He is an associate member of the American Institute of Electrical Engineers.

Engineering Affairs

The National Gas Engine Association will hold its twelfth annual meeting, in Chicago, June 2-3, with headquarters at the Hotel Sherman.

New York Association No. 44, N. A. S. E., held its annual Spring Hike on Sunday, May 18. Dinner was served at the Lincoln Hotel, Midland Beach, S. I. The attendance almost doubled that of the previous walk.

The West Virginia Public Utilities Association will hold a convention at White Sulphur, June 4-7. This is the first convention to be held by this association since the beginning of the war. A large attendance is expected.

The Combined Associations of the N. A. S. E. of Boston, Mass., including Nos. 1, 12 and 14, held a ladies' night at the Engineers' Hall on Saturday, May 17. Many prominent in the engineering field were present. An enjoyable entertainment was followed by dancing, and refreshments were liberally served. James H. Henderson was the master of ceremonies.

Business Items

The Advance Heating Co. has moved into larger quarters at 110 N. Desplanes St., Chicago, where its office and shop facilities are now combined.

The Standard Electric and Elevator Co., of Baltimore, Md., has opened a New York City office at 280 Broadway, with C. A. Yarrington in charge.

The Staunton Lighting Co., Staunton, Va., announces the following change in its personnel: James R. Wampler is now superintendent and J. W. Coffman is chief engineer.

Paul W. Koch & Co., have opened Pacific Coast offices at the following addresses: Los Angeles, 114 San Fernando Building; San Francisco, 324 Rialto Building; Portland, Oregon, 342 Sherlock Building. These offices will take care of business on the "Jiffy" adjustable cutter, speed punch and other "Jiffy" labor-saving tools.

Trade Catalogs

Foxboro Recording Psychrometers. The Foxboro Co., Inc., Foxboro, Mass. Bulletin No. 103-1. Pages 11, 8 x 10½ in. The most complete bulletin yet published on this subject.

The Griscom-Russell Co., New York City, has issued its 15-page Bulletin No. 230, descriptive of the "Reilly Water Heater." The opening pages are devoted to chapters on feed water heating and on how to compute the savings resulting from use of a proper feed water heater.

The Portable Machinery Co., Inc., Passaic, N. J., has recently published a 20-page folder entitled "Over 1000 Scoop Conveyors." It is well illustrated and shows the various uses, labor, time and money-saving features of the machine. Copy may be had free upon request.

E. Keeler Co., New York City, has recently issued a nicely bound 22-page catalog on "Cross Drum Water Tube Boilers." It is well illustrated and contains some very useful information. The last two pages are devoted to a brief description of the Keeler water-tube boiler and the Keeler return-tubular boiler.

The Liberty Manufacturing Co., Pittsburgh, Penn., has issued a new 40-page catalog "Z" of useful reading matter on the company's line of apparatus. The introductory pages on boiler-tube cleaners and the operation of turbine cleaners are especially interesting. Various types of cleaners are shown and discussed.

The American Steam Gage & Valve Manufacturing Co., Boston, Mass., has just issued a nicely embossed 31-page booklet entitled "The American Thompson Improved Indicator." This booklet fully illustrates and describes the Thompson indicator and its accessories with price list, and devotes some space to the general use and care of the instrument. A few pages are also devoted to directions for using the planimeter.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2 15@2.75	$2.75@3 25
Philadelphia, gross tons	4 27@4.95	5.95@5 50
New York, gross tons	4.62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4·70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7 90	Pea	4 90	6.65
Egg	5.95	7 80	Buckwheat	3.40	5.15
Stove	6 20	8 05	Rice	2 75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2 75 @ 2 95	2.95 @ 3.25
Clearfield County	2.50 @ 2.75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2 75 @ 2.95
Quemahoning	2.65 @ 2.85	2.95 @ 3.10
Somerset County (best grades)	2.65 @ 2.85	2.95 @ 3.10
Somerset County (poorer grades)	2.00 @ 2.35	2.50 @ 2.75
Western Maryland	2 25 @ 2 75	2.50 @ 2.75
Fairmont	2.00 @ 2 25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2.25 @ 2.40
Greensburg	2.25 @ 2 35	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.60 @ 2.75
Westmoreland run-of-mine	2.35 @ 2.60	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7 80	Buckwheat	$3.40	$4.45
Egg	5.95	7 80	Rice	2.75	3 65
Stove	6.20	8.05	Boiler	2.50	3.50
Nut	6 30	8.15	Barley	2.25	3.15
Pea	4.90	6 50	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3 40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2.00@2.25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; other rates 92½c.

New Construction

PROPOSED WORK

Mass., Springfield—The National Equipment Co., 662 North Main St., will install a heating plant and electric power in the 3 story addition to its factory on North Main St. Total estimated cost, $200,000.

Mass., Warren—The Warren Steam Pump Co. plans to build a 1 story, 40 x 130 ft. boiler house and a 1 story 85 x 200 ft. factory, etc., at its plant. Estimated cost, $75,000.

Conn., Bridgeport—The Fletcher-Thompson, Inc., Engrs., 1089 Broad St., will soon receive bids for the construction of a 1 story, 65 x 100 ft. and a 1 story, 60 x 65 ft. ice plants; also a 1 story, 100 x 150 ft. cold storage building on Seaview Ave., for the Peoples Ice Co., c/o F. E. Ballard, 44 Wood Ave. Estimated cost, $150,000.

Conn., Manchester—The town will install a steam heating plant in the 3 story, 45 x 90 ft. memorial hospital which it plans to build on Haynes St. Total estimated cost, $80,000.

Conn., New Haven—The Yale Tire & Rubber Co., 827 Elm St., plans to build a factory and power house on Dixwell and Homden Ave. Estimated cost, $100,000. J. E. Hubinger, Pres. Engr. not selected.

N. Y., Border City—The Empire Gas & Electric Co., 103 Castle St., Geneva, has purchased a 100 acre site adjacent to its plant here and bordering on the Barge Cayuga and Seneca Canals and plans to build a terminal, pumping station with 2 motor driven pumps, 2,500,000 gal. daily capacity. C. F. Brunt, Geneva, Supt.

N. Y., Brooklyn—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build an extension to the heating plant and distributing system at the naval hospital here. Estimated cost, $830,000. Specification No. 3891.

N. Y., Brooklyn—The St. Brendons Roman Catholic Congregation, 1525 East 12th St., will install a steam heating plant in the 86 x 140 ft. addition to its church on Ave. O and East 12th St. Total estimated cost, $100,000. E. T. Lynch, 341 5th Ave., New York City, Arch.

N. Y., Central Islip—The State Hospital Commission, Capitol, Albany, will receive bids until June 4 for the construction of a 3 story, 30 x 296 ft. addition to building for acute patients, at the Central Islip State Hospital here. A heating plant will be installed in same. Total estimated cost, $150,000.

N. Y., Lake Placid—The Bowman Hotel Co., Hotel Biltmore, 43rd St. and Madison Ave., New York City, has awarded the contract for the construction of a 10 story hotel here, to the Hegeman-Harris Co., Inc., 33 West 42nd St., New York City. A steam heating plant will be installed in same. Total estimated cost, $300,000.

N. Y., Montauk—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until June 11 for the construction of a power house here. Estimated cost, $40,000. Specification No. 3889.

N. Y., New York—The Seven Hundred West End Corp., 280 Madison Ave., will install a steam heating system in the 14 story, 44 x 100 ft. hotel which it plans to build on West End Ave. and 94th St. Total estimated cost, $250,000. G. T. Pelham, 200 West 72nd St., Engr.

N. Y., Ossining—C. F. Rattigan, Supt. of State Prisons, Hall of Records Bldg., Center and Chambers St., New York City, will receive bids until June 17 for the construction of a 25 x 27 ft. pump house and a 36 x 90 ft. reservoir, also for a heating plant and the installation of 2-400 hp. boilers in the power house. L. F. Pilcher, Capitol, Albany, State Arch. Noted May 13.

N. Y., Poughkeepsie—The State Hospital Commission, Capitol, Albany, will receive bids until June 4 for the construction of a 20 x 25 ft. pump house and installing 2 pumps in connection with the additions and alterations which it plans to the water supply system at the Hudson River State Hospital here. L. F. Pilcher, Capitol, Albany, N. Y., State Arch. Noted Feb. 4.

N. Y., Rome—The Rome Gas, Electric Light & Power Co., 139 North James St., plans to issue $245,164 bonds for the construction of a gas and electric plant. A. B. Morton, Supt.

N. Y., Watervliet—P. J. Mattou Boat Building Co., 1 Ide Ewey, will install pumps at the 1000 ton dry dock which it plans to build at the company's plant here.

Penn., Altoona—The Altoona Bakery Co. will install 4 boilers in the 2 story, 115 x 150 ft. bakery which it plans to build on 28th St., from 9th to Industrial Ave. R. W. Nash, Pres.

Penn., Blairsville—The Western State Hospital for Insane, Altoona, is having plans prepared by Crook & Cooley, Archts., Jones Law Bldg., Pittsburgh, for the construction of a hospital and group of institutional buildings near here to consist of power house, laundry, reservoir, etc. Total estimated cost, $2,000,000. G. S. Idell, 31 South 16th St., Philadelphia, Consult. Arch.

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C. will receive bids until June 4 for installing heating and humidifying apparatus at the air craft storage plant here. Estimated cost, $75,000. Specification No. 3854. Noted Apr. 22.

Penn., Philadelphia—W. Hutchinson, Jr., will install a steam heating plant in the 6 story theatre and apartment which he plans to build on Queens Lane and Schuyler Rd. Total estimated cost, $450,000. Fisher & Jones, Westinghouse Bldg., Pittsburgh, Arch.

D. C., Washington—The Bureau of Supplies & Accounts, Navy Department, will soon receive bids for furnishing motor generator and telephone, delivery Mare Island, Cal., and Brooklyn, N. Y. Schedule No. 3693.

W. Va., Weston—The State Board of Control, Charleston, will receive bids until June 14 for the construction of sewage treatment works at the Weston State Hospital here. Plans include sewage pumping station equipped with 2 electric motors, 2 centrifugal pumps and automatic control equipment, etc. J. S. Larkin, Member.

Fla., Key West—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build a power house and fire protection system here. Estimated cost, $20,000. Specification No. 3896.

Ind., Indianapolis—The G. & J. Tire Co., 549 East Georgia St., will install a 45 x 60 ft., 36,000 hp. steam boiler plant in connection with the 5 story, 100 x 400 ft. plant which it plans to build. Total estimated cost, $950,000. Lockwood, Greene & Co., 38 South Dearborn St., Chicago, Ill., Engr.

Ind., Whiting—The Board of Public Works will receive bids until June 2 for one 5,000,000 centrifugal pump, two 5,000,000 gal. centrifugal pumps, one 3,000,000 gal. trifugal pumps, 1 wash water pump and 1 trifugal pump, 1 wash water pump and 1 switchboard and equipment. S. A. Greeley, 39 West Adams St., Chicago, Ill. Engr.

Mich., Detroit—The Academy of Music, c/o C. H. Crane and E. G. Kiehler, Archts., Dime Bank Bldg., will install steam heating equipment, boiler, fans and motor in the 2 and 3 story, 100 x 171 ft. store and auditorium building which it plans to build on Woodward Ave. and Parsons St. Total estimated cost, $350,000.

Mich., Grand Rapids—Mueller & Slack Co. plans to install a new 150 hp. steam engine. J. W. Stevens, Ch. Engr.

Mich., Lansing—The Hotel Michigan Co. will install a steam heating plant in the 12 story, 98 x 140 ft. hotel which it plans to build on East Michigan Ave. Total estimated cost, $630,000. C. Allen, Jackson, Arch.

Mich., Mt. Pleasant—The Transport Truck Co. plans to build a 1 story, 40 x 50 ft. power plant and a 150 x 300 ft. assembling plant. Plans include the installation of a separate steam unit in the power plant. Total estimated cost, $80,000. J. J. Bachman, Arch.

Mich., Oakwood (Oxford P. O.)—The village will install modern steam heating apparatus in the 2 story high school building which it plans to build. Total estimated cost, $230,000. Van Leyen & Schiller & Keough, Union Trust Bldg., Detroit, Arch.

Ill., Chicago—The Central Film Exchange, c/o Berlin & Swern, Archts., 19 South La Salle St., will install a steam heating plant in the 12 story, 95 x 165 ft. exchange building which it plans to build on Wabash Ave. and 9th St. Total estimated cost, $1,200,000.

Wis., Kenosha—The County Board will install a low pressure steam heating system and vacuum vapor system, (Bishop Babcock preferred) in the 4 story, 114 x 168 ft. court house which it plans to build on Park St. Total estimated cost, $400,000. White, White & White, P. S. Bldg., Arch.

Wis., Winona—The city will soon receive bids for 4 air lift pumps, having a capacity of from 200 to 400 gal. each and miscellaneous appurtenances to be installed at the waterworks.

Minn., Wells—The city will soon receive bids for the construction of a new power plant building, electrical distribution system and concrete reservoir. Estimated cost, $40,000. C. L. Pillsbury Co., 801 Metropolitan Life Bldg., Minneapolis, Engr.

Mo., Ozark—E. Hawkins, Arch., 419 Holland Bldg., Springfield, will receive bids until June 2 for furnishing heating and plumbing for the court house here.

Mo., St. Louis—Hall & McKay, contractors, Chemical Bldg., will receive bids for a power plant to include 2 large electric elevators, new generators, engine, pump, etc., for the Kennett Building, B'way. and Locust St.

Okla., Miami—T. L. Green, Consult. Engr., Miami, would like to receive catalogs and prices on oil and gas engines, pumps, motors, compressors, air receivers and other air lift equipment, motors, starters, generators, panel boards and other electric equipment necessary to the installation of electric light and pumping plants.

Cal., Los Angeles—The Anheuser-Busch Co., 9th and Pestalozzi St., St. Louis, Mo., plans to convert its bottling plant here into an ice factory and cold storage plant and build an ice cream factory adjoining same. G. E. Wells, Engr.

Ont., Barry Sound—The citizens plan to vote on $100,000 by-law June 21 for the construction of a power plant. R. J. Hall, Mayor.

CONTRACTS AWARDED

Mass., Campello—A. E. Kieth Co., Station St., Brockton, has awarded the contract for the construction of a 2 story, 60 x 70 ft. power house here, to Westcott & Mapes, 207 Orange St., New Haven. Estimated cost, $100,000.

Conn., Bridgeport—The Baptist Christian Union, Inc., 886 Main St., has awarded the contract for installing a heating plant in the 4 story, 80 x 102 ft. home on Main and Thomas St., to N. P. Kirk Co., 319 Main St. Noted Jan. 7.

Conn., Bridgeport—The Home Brewing Co., 226 Hallam St., has awarded the contract for the construction of a 1 story, 150 x 150 ft. artificial ice plant, to the Schwarz Bros. Co., 95 River St. Estimated cost, $200,000.

N. Y., Brooklyn—R. Gair Co., 50 Washington St., has awarded the contract for the construction of an addition to its boiler house on Plymouth St., to the Turner Construction Co., 244 Madison Ave., New York City.

N. Y., New York—A. J. Schwartzler, 369 East 167th St., will build a 2 story, 122 x 190 ft. ice plant on Fordham Rd. and Cedar Ave. Estimated cost, $45,000. Work will be done by day labor.

Fla., Pensacola—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing electric equipment in the central power plant here, to the Carroll Electric Co., 714 12th St., Washington, D. C. (150 days.) Noted Feb. 18.

Ohio, Bryan—The Trustees of Public Affairs has awarded the contract for the construction of a 1,000,000 gal. concrete reservoir and pump house, to the Toledo Residence Construction Co., 322 Nasby Bldg., Toledo. Estimated cost, $23,700.

Mich., Detroit—The Detroit Edison Co., David Whitney Bldg., will build a 55 mi. transmission line between here and Port Huron. Work involves 60 ft. poles set 40 to the mile, supporting copper cable transmitting 66,000 volts. Work will be done by day labor.

Ill., Chicago—Morris & Co., Union Stock Yards, has awarded the contract for the construction of a 9 story, 150 x 350 ft. cold storage warehouse on 44th and Loomis St., to R. C. Wieboldt, 1534 West Van Buren St. Estimated cost, $1,000,000.

Mo., St. Joseph—Swift & Co., Union Stock Yards, Chicago, Ill., has awarded the contract for the construction of a 2 story, 42 x 110 ft. addition to its cold storage plant on Packers Ave., to the Lehr Construction Co., 1712 Frederick Ave. Estimated cost, $30,500.

Tex., Goose Creek—The Humble Oil & Refining Co., Goggan Bldg., Houston, has awarded the contract for the construction of a group of buildings here, to consist of boiler shops, power and pump houses, ice plant and repair shops, etc., to the Turner Construction Co., 244 Madison Ave., New York City.

Read the

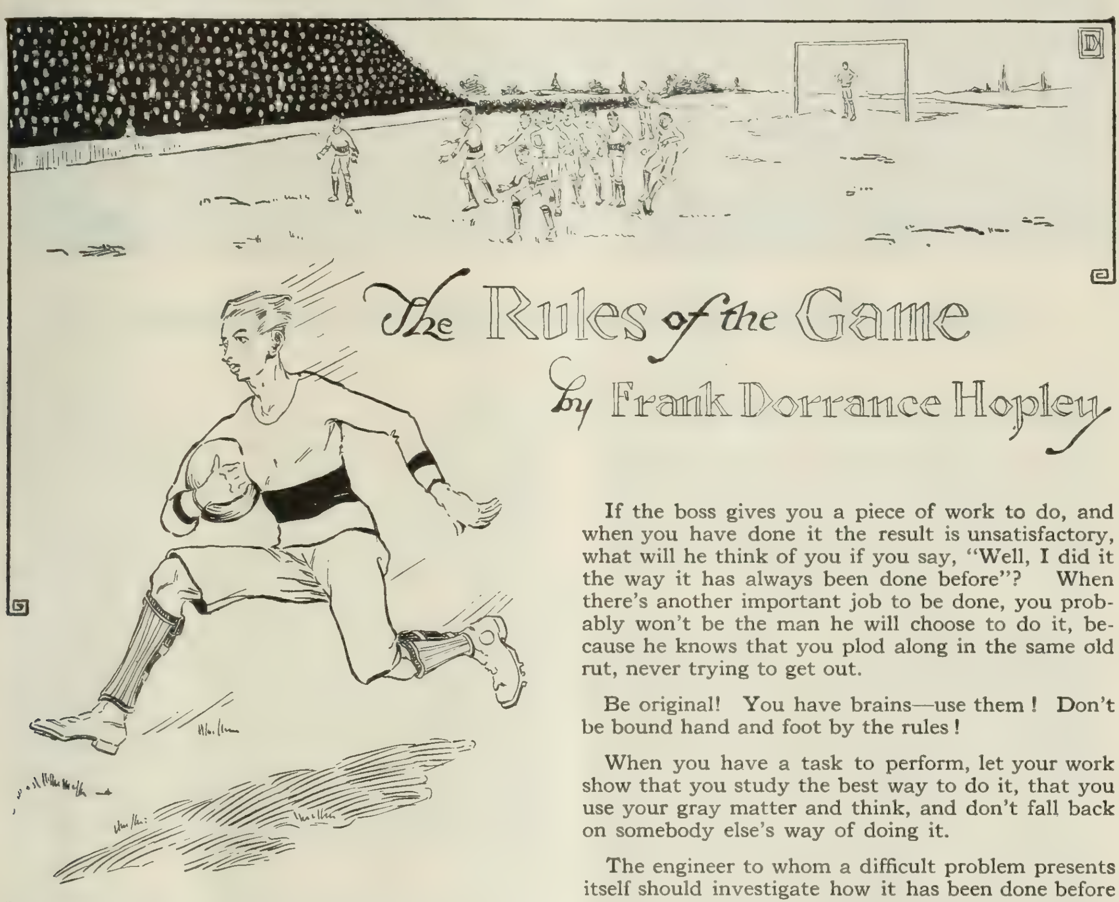
SEARCHLIGHT SECTION

The
"Opportunity" advertising
of the
Power Plant Field

See pages 55 to 67

POWER

Volume 49 New York, June 3, 1919 *Number* 22



The Rules of the Game

by Frank Dorrance Hopley

IN Cambridge, England, there is a tablet erected in memory of a man who, when playing a game of football, took the ball and ran down the field with it. By doing this he broke the rules of the game but he invented the game of Rugby, which has since become famous.

This incident only goes to show that the fellow who does things "according to Hoyle" is not always the man who "gets there." Persistently following rule of thumb is likely to lead a man up a blind alley.

The engineer, the mechanic or the workman who does a thing in a certain manner because it has always been done that way in the past is losing the opportunity for self-advancement and new power.

Initiative is a long word, but it means working out your own ideas in your own way and not according to the rules laid down by someone else.

If the boss gives you a piece of work to do, and when you have done it the result is unsatisfactory, what will he think of you if you say, "Well, I did it the way it has always been done before"? When there's another important job to be done, you probably won't be the man he will choose to do it, because he knows that you plod along in the same old rut, never trying to get out.

Be original! You have brains—use them! Don't be bound hand and foot by the rules!

When you have a task to perform, let your work show that you study the best way to do it, that you use your gray matter and think, and don't fall back on somebody else's way of doing it.

The engineer to whom a difficult problem presents itself should investigate how it has been done before and then bend all his energies to find a way by which it can be done better. The man who does that is the man who one day finds himself at the very top of the ladder.

Just remember the fellow who grabbed the ball and ran with it down the football field. He broke the rules of the game but he made himself famous.

Fame may not come to you. In all probability there will be no tablet raised to your memory. But if you use your head and show that you know how to plan your work, always looking for a new and better way to do the thing you have to do, there will be a whole lot more money in your pocket at the end of the year, which in these days is much to be desired.

Break the rules of the game once in a while and see what happens. You will not be disappointed.

Brule River Hydro-Electric Development

BY C. V. SEASTONE*

Outline of Peninsular Power Co. system with detailed description of latest hydraulic development on the Brule River. A three-unit modern plant generating three-phase 60-cycle current at 6600 volts. Vertical shaft turbines operate under a head approximating 60 feet.

THE Peninsular Power Co. is completing a hydro-electric development on the Brule River at a location about three miles from Florence, Wis. The construction of this plant was begun in June, 1917, and efforts are being made to finish it early in 1919.

Below Florence the Michigamme River flows into the Brule and the two streams unite to make the Menominee River. Early in 1913 the Peninsular Power Co. completed its first hydro-electric development on the Menominee River at a point commonly known as Twin Falls, near Iron Mountain, Mich. This plant has a machine capacity of about 5500 kw. The company also has a 3500-kw. auxiliary steam plant at its principal substation at Iron River, Mich. A 66,000-volt transmission line connects the Twin Falls plant and the substation at Iron River, Mich. The Brule River plant will be connected to the main transmission system, requiring about three miles of line. The company furnishes electrical power to the iron mines in the vicinity of Florence, Wis., Iron Mountain and Iron River, Mich., and to various villages and towns in that vicinity.

According to the general layout of the proposed hydro-electric development the Brule River is divided at this location by an island that is approximately 1000 ft. long. In the south channel between the island and the Wisconsin shore are the power house and the main concrete dam, the latter being flanked on the Wisconsin side by a concrete abutment and earthen section. Flood discharge is provided for by the installation of eight tainter gates, each 12 ft. high and 14 ft. long. These gates are constructed on the island and discharge into the north channel, which is independent from the discharge from the power house.

In the north channel is to be constructed an earthen dam provided with a concrete corewall. All the construction work is founded upon solid rock with the exception of a length of about 70 ft. of the corewall in the center of the north channel. Evidently the north channel was the original bed of the stream. Excavation to a depth of about 18 ft. below the bottom of the river revealed a solid bed of boulders of varying sizes up to several cubic feet each. It was not considered essential to carry the excavation to solid rock in this section as it is believed from the character of the material encountered that the seepage will be nominal. The average working head provided by the dam is 60 feet.

The cross-section of the concrete dam between the power house and the abutment on the Wisconsin shore is about 70 ft. long and supports piers on the downstream side on which is constructed a concrete roadway to the power house. Under-drainage is provided by a 12-in. vitrified-tile drain placed longitudinally with the dam, as indicated, and connecting with 12-in. lateral drains at right angles to the collecting drain.

To determine the effect of upward pressure under the dam, if any exists, 1-in. iron pipes have been placed as indicated on the drawing. Their upper ends at the rock surface terminate in sheet-iron funnels 12 in. diameter, care being taken during construction to see that no concrete was placed under the funnel. A line of pipes of similar character and arrangement was also placed under the power house. It is believed that after the construction is completed and the head raised, the above may afford some opportunity for observing the extent of the upward pressure and thus furnish information that may be of some value.

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*Daniel W. Mead and Charles V. Seastone, consulting engineers, Madison, Wis.

Fig. 3 is a cross-section of the tainter gate spillway. Six of the gates are provided with hand hoists so designed as to later admit of electrical operation, and two of the gates have electric hoists. A concrete counterweight as shown is provided to reduce the force required to lift the gates.

The earthen section in the north channel is provided with a concrete corewall 5 ft. thick at the stream bed and 2 ft. thick at the top. This corewall is well anchored to rock walls on both ends and is founded on rock except a section of about 70 ft. in the center of the channel. The earthen section has a 3 to 1 slope on the upstream side and a 2 to 1 slope on the downstream side. The upstream side to a point about 20 ft. below the normal water surface will be riprapped with stone.

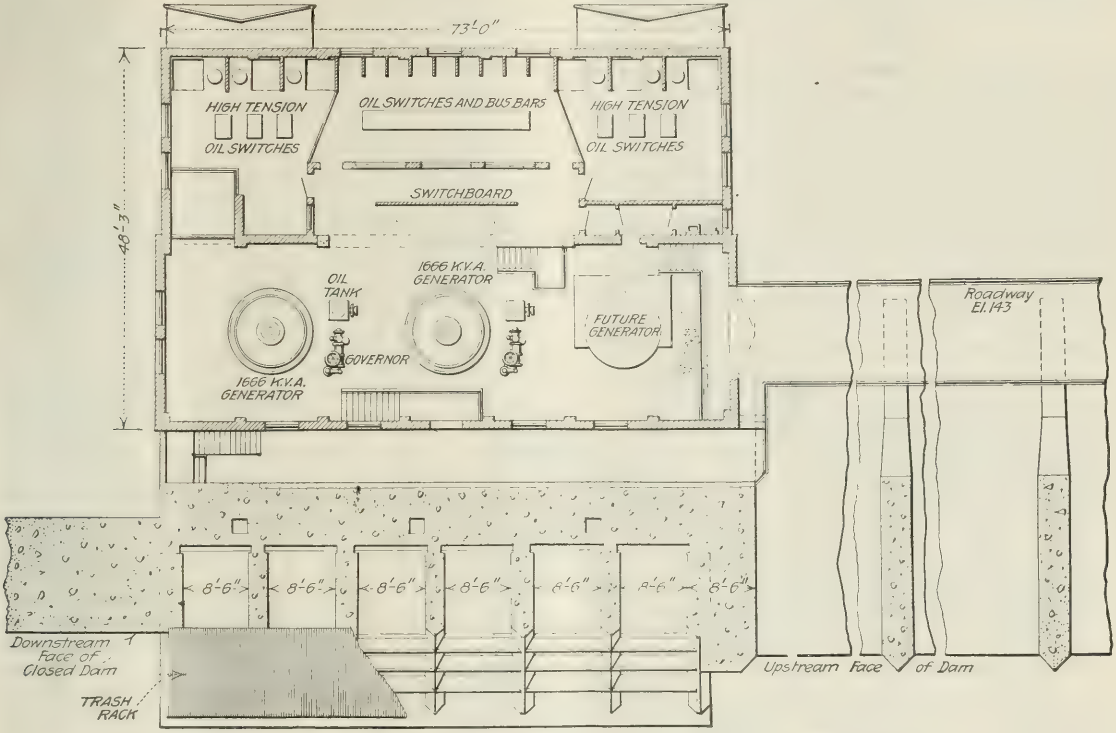

FIG. 1. PLAN VIEW OF THE POWER HOUSE, GIVING CHIEF DIMENSIONS

An upstream view of the power house is shown in the headpiece and Fig. 2 is a cross-section through the plant. The foundations, wheel pits and forebay are of concrete construction, and the superstructure is of common brick laid in a chocolate-colored mortar. The switchboard is on the same floor level with the generators and the transformers are on the floor below.

Fig. 1 is a sectional plan at the generator-room floor level. As the transformers are below this level, an opening is provided which permits of raising them to the main floor, and a suitable chain hoist is provided for this purpose. The cross-section, Fig. 2, shows the location of the pipes that have been placed for observing the extent of the upward pressure. The penstock gates, of which there are two for each unit, are operated by electrically driven geared hoists.

Although completed for the installation of three units, the power house at present has two machines, each consisting of one 56-in. vertical-shaft Leffel turbine, furnished with shaft extension for direct connection to a vertical-shaft generator, governor, oil-pressure pump, piping and valves. When operating under a head of 60 ft., each turbine will develop 3100 hp. at 240 revolutions per minute. The turbines are installed in concrete scroll cases and are mounted on concrete curved draft tubes. The turbines are guaranteed to give the following efficiencies:

Per cent. power..	100	95	90	80	70	60	50
Per cent. effic....	80.9	87.6	88.5	87.4	84	81.4	78.7

For regulating the speed of the turbines, Woodward 21,000-ft.-lb. oil-pressure relay-valve governors are installed.

The generators are 2000-kv.-a. three-phase 60-cycle 6600-volt vertical Westinghouse machines, each provided with two guide bearings and a Kingsbury thrust bearing. A 60-kw. 125-volt shunt-wound direct-connected exciter, designed for operation with a Tyrill regulator, serves each generator.

There are four 1667-kv.-a. single-phase 66,000-6600-volt transformers provided, one constituting a spare unit. These transformers are equipped with copper cooling coils and three are mounted upon a suitable track. The spare unit has been placed upon a truck to facilitate moving to place.

The switchboard, of Westinghouse design, is centrally located on the same floor elevation as the generators and low-tension busbars. It consists of nine panels of natural black slate and one swinging bracket, as follows: One low-tension station lighting panel, one low-tension station power panel, a direct-current emergency control unit panel, an exciter panel, three generator panels and two feeder panels. On the swinging bracket are mounted the synchronoscope, frequency meter, direct-current voltmeter, alternating-current voltmeter and alternating-current ammeter. The main control rheostat is mounted on pipe framework above and back of the board proper. All but the future generator panel are furnished with the necessary control lights, switches, meters, voltmeter receptacles and relays.

The location of the switchboard is such that the operator, standing at either end of the board, can see the three generators, the six high-tension oil switches, the low-tension oil switches, busbars and instrument compartments. By this arrangement a flashover in any part of the building on this floor can be located immediately and repairs made quickly.

A single-line diagram of the electrical connections is shown in Fig. 4. Either or both generators may be used to supply the demand, and disconnecting switches permit cutting out of service any of the feeder circuits.

The control wires are carried in metal conduits from the low-tension busbar, instrument compartments and machines. The system is ordinarily operated by 110-volt current from the exciter bus, but provision has been made for emergency control and lighting by the installation of a 10-hp. turbine direct-connected to a 9-kw. 125-volt generator. In connection with this unit a separate or emergency system of lighting has been installed throughout the building, so that all possible haste may be made in repairing damaged equipment or replacing equipment destroyed by lightning or otherwise.

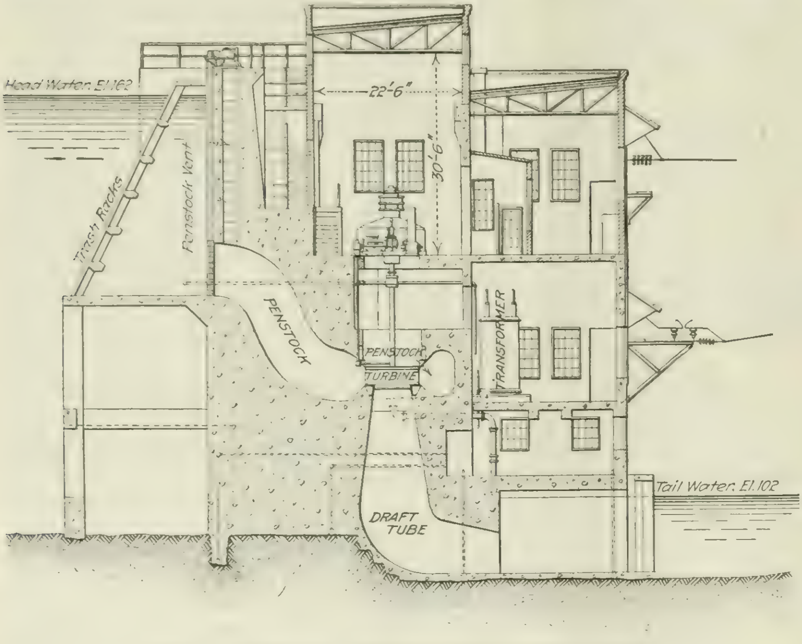

FIG. 2. SECTIONAL VIEW OF THE POWER HOUSE

The main substation, located at Iron River, Mich., contains six 420-kv.-a. single-phase transformers of the oil-insulated, water-cooled type. They are Y-connected on the high-tension side, receiving 66,000 volts between the leads, and delta connected on the low-tension side, delivering 6600 volts. The auxiliary steam plant adjacent to the substation contains three condensing turbine units of a total capacity of 3500 kw. Four 450-hp. internally fired boilers, equipped with Hawley down-draft furnaces, supply the steam. They are served by a reinforced-concrete stack 8 ft. diameter and 150 ft. high. The main transmission line consists of about 45 miles of 66,000-volt lines connecting the hydraulic plants at the Brule and Twin Falls locations with the mining districts of Iron River and Alpha, Mich., and Florence, Wis. The line is in duplicate and is carried on steel towers set in concrete bases. Power is delivered to each mine from the high-tension substation at 6600 volts and is stepped down to 2200 volts for general distribution around the mines. Practically all the secondary lines are in duplicate and are carried on steel towers. Secondary substations are installed at each mine by the power company, the customer providing the necessary building. The equipment consists of three single-phase transformers, automatic oil switch, control panel with all necessary instruments, relays and measuring transformers, and complete sets of electrolytic lightning arresters and choke coils. The secondary substations carry a typical mining load consisting of air compressors, pumps, hoists, motor generators for underground haulage, crushers, blowers, shop

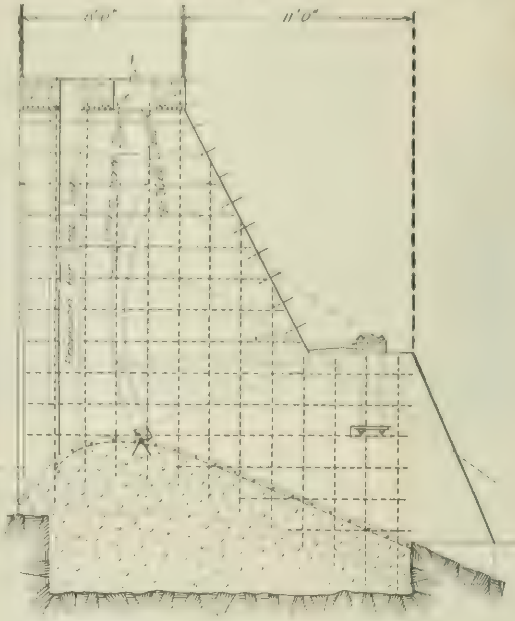

FIG. 3. SECTION TAINTER GATE SPILLWAY

motors and lighting above and below surface. Motors of 25 hp. or over are with but few exceptions operated at 2200 volts. This practice of furnishing power to these iron mines is much the same as that now carried out with several coal mines in other sections of the country, the great plant at Windsor, W. Va., and those of the Appalachian Power Co. being typical examples.

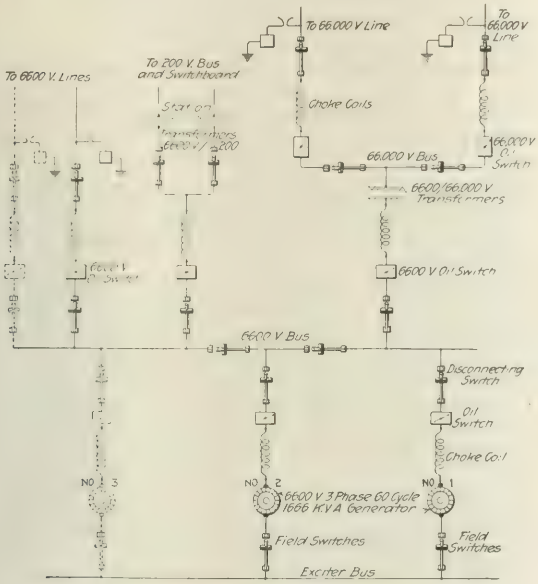

FIG. 4. DIAGRAM OF ELECTRICAL CONNECTIONS

Checking Motor Field Coils

By E. C. Parham

Even where hundreds of field coils of the same kind are made yearly, mistakes in marking the terminals occasionally occur and these mistakes inevitably give trouble and expense. The percentage of mistakes found on factory-made coils is so very small that it is customary to accept their markings as correct and to install the coils accordingly. Where spare coils are made by repairmen or where there is for any reason doubt as to the markings or where there are no markings, considerable delay and expense may be saved by subjecting the coils to preliminary polarity test. Especially is this course advisable where a heavy machine is involved or where lifting facilities for handling the machine are poor.

After trying out a large 500-volt six-pole shunt-wound direct-current motor, it became evident that a compound-wound motor was needed for the work. A set of field coils was obtained from a local repair shop. The terminals of the coils were not marked and the manner of bringing out the leads was not evident. In order to avoid installing the coils to give wrong polarity, they were arranged as shown in Fig. 1, before installation, and the adjacent terminals of the shunt coils were connected as indicated. Line voltage was then applied to the series of shunt windings and a compass used for indicating their polarities. It was necessary to turn one coil end for end in order to have the polarities alternate N and S.

Leaving the coils in position, Fig. 1, the series coils were connected in series and current passed through them and their polarity tested. Of course a heavier current was required for testing the series coils, and in order to get a current that would give definite compass testing result, it was necessary to pass through the coils the operating current of a neighboring motor by making connections as shown in Fig. 2. The result of the test was to locate a reversed series winding on one of the coils. Therefore, in installing this coil in the motor it was turned end for end, which reversed the polarity of the shunt winding of that coil, if it were to be connected up symmetrically. In order to rectify these conditions, the connections to the shunt winding of this coil were crossed, which did not make a very good-looking job, but saved considerable time in getting the machine into service. After the coils were in the motor, the tests were repeated and everything was found to be all right. As a final check, made in order to insure that the shunt windings and the series windings would operate the armature in the same direction, the motor was started; first, by means of the shunt coils and then by means of the series coils alone. In doing this care must be exercised not to cut the starting resistance out when the machine is operating as a series motor, or it will race and may injure the armature.

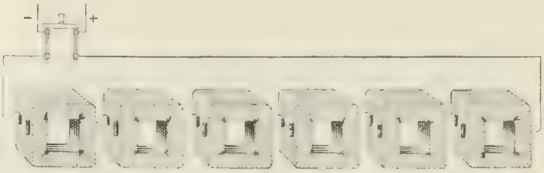

FIG. 1. CONNECTIONS FOR CHECKING SHUNT-FIELD COILS BEFORE INSTALLATION

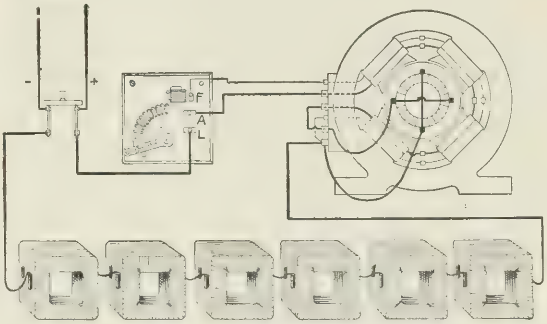

FIG. 2. CONNECTIONS FOR CHECKING SHUNT-FIELD COILS BEFORE INSTALLATION

A pump may operate stiffly with uneven strokes owing to the swelling of fibrous packing in the water plungers, particularly if the liquids pumped are hot. The swelling is usually lateral so that a layer may be stripped from one side to thin the packing down. New packing should soak over night in warm water and should be loosely packed in the space provided, so that when put to work it will swell and fit as required.

The title of the article on page 759 of the May 20 issue of *Power* should read "Blauvelt" instead of "Du Bois Piston Ring" etc. This ring can be obtained from F. N. Du Bois & Co., 9th Ave. and 25th St., New York City.

Pulling Conductors into Conduits[*]

BY TERRELL CROFT

Discusses the different methods of installing conductors into conduit and the precautions that must be observed to do the work properly.

METHODS of installing conductors in conduit runs which are in position may be classified under three different headings; namely, drawing, threading and pushing. Drawing consists in pulling the conductors into the conduit by means of a pulling-in line of one sort or another to which the conductors have been temporarily attached. Threading consists of threading the conductors through the conduit as it is erected length by length. This method, while it is used to some extent in England and on the continent, is never followed in North America because our electrical codes specify that "the conductors must not be pulled in until the conduit system has been erected as a complete unit." Pushing consists in forcing the conductors through the conduit run from one of the outlets by exerting manual pressure on them. This method is applicable only where the conduit run in which the conductors are to be installed is short and straight; that is, it can be used only for "easy runs."

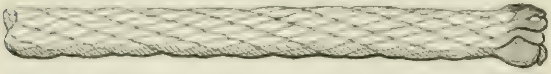

FIG. 1. BRAIDED CORD FOR PULL-IN LINE

Galvanized steel wire makes an excellent pulling-in line, No. 10 or 12 B. W. G. being ordinarily used. If one strand of the wire is not sufficiently strong to sustain the stress imposed, several strands arranged in parallel can be used.

Rope or cord pulling-in lines are probably used more frequently than the other types. Braided rope, Fig. 1, of the construction of that used for sash cord, is ordinarily used for rope pulling-in lines, although in many cases, for heavy-pulling runs, galvanized-steel wire is better. Twisted manila rope is sometimes used, but it tends to untwist when subjected to tension. The insertion of a swivel, Fig. 2, between the end of a twisted-rope pulling-in line and the conductors to be drawn in will, in a measure, obviate this difficulty. In untwisting, the rope twists the conductors within the conduit, which causes them to "pack" and pull hard around the elbows. Braided rope, or, as it is called by the trade, "cord," is manufactured in a variety of diameters from $\frac{7}{32}$ in. up to $\frac{1}{2}$ in., and sometimes cords of larger diameters may be obtained. Steel hoisting cable such as that used on cranes has been tried by the writer for pulling-in lines, but because of its high cost and tendency to cut when tied to a tackle-block hook, it was not found satisfactory.

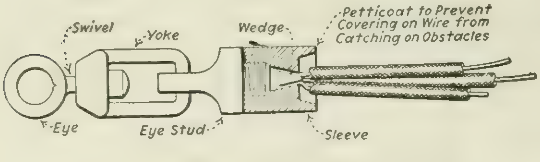
Swivel
Yoke
Wedge
Petticoat to Prevent Covering on Wire from Catching on Obstacles
Eye
Eye Stud
Sleeve

FIG. 2. SWIVEL TO PREVENT TWISTING

Galvanized-steel wire is better than rope for heavy work. The rope is much more bulky for the same strength, is more expensive and wears out more quickly under severe usage. It is difficult to tie a rope to the hook of a set of tackle blocks with a knot which will not cut and thus sever the line. Galvanized-steel wire can be quickly and positively secured to a tackle-block hook through the agency of a wire grip similar to that shown in Fig. 3.

Steel sash chain makes a good pulling-in line for some purposes. It is very strong, flexible, readily obtained and economical. That of the construction of Fig. 4 has been found very satisfactory. Conductors to be drawn in can be readily attached to the sash-chain line at any point by tying them into the links. This feature is particularly convenient where there are a number of outlets along a run and conductors that are to terminate in each are to be drawn in simultaneously. In pulling conductors into a vertical run, the sash chain may, of its own weight, be dropped down through the tube, rendering fishing unnecessary.

Excessive force should not be necessary to draw the conductors into the conduits. This caution should be interpreted in a relative sense. It should always be possible to pull No. 14 conductors into the ducts with the hands, where heavy cables may require a tackle or a crane. In any event, the conduits should be large enough so that there is plenty of room in them for the conductors, and there should be few elbows between pull or outlet boxes. Undersized ducts and an excessive number of elbows or bends will render pulling in extremely difficult and may, after the conductors have become "set," make withdrawal impossible. One of the features which recommends the conduit system of wiring is that, with a properly designed system, the conductors can be withdrawn or pulled in at any time.

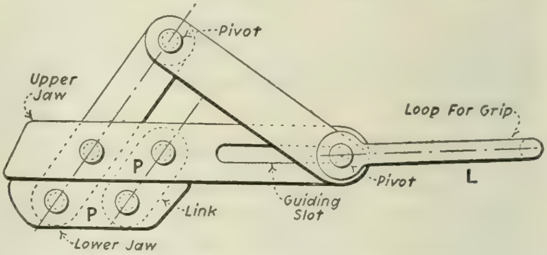

FIG. 3. PARALLEL-JAW WIRE GRIP

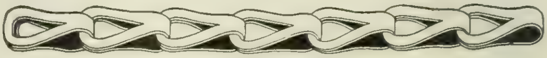

FIG. 4. CHAIN PULL-IN LINE

Prior to pulling in the conductors, the interior of the conduit should be cleaned. Sometimes oil, water, plaster, cement and dirt accumulate inside of the tubes while the building is being constructed. Obviously, these materials should be removed before conductors are drawn in. A rapid and effective expedient for cleaning a conduit is to pull a piece of waste through it before drawing in.

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[*] Copyright, 1919, by Terrell Croft.

Lubrication of some sort is desirable when pulling large-sized conductors into conduit. Particularly is it necessary in hot weather and for long runs. When the insulating compound on the conductors is warm, it seeps through the braid and may adhere to the interior surface of the tube.

Powdered soapstone, sometimes called French chalk, is probably the best lubricant. It may be either blown into the conduit with a piece of hose or applied to the conductors as they are pulled in. In blowing powdered soapstone into the duct, a piece of rubber hose about two feet long is partly filled with the material. One end of the hose is held against the bushing at the conduit opening so as to fill the orifice. Then the wireman blows on the other end of the hose with his mouth, forcing the powder inside of the tube. The wires manufactured by some concerns have a coating of powdered mica applied to the outer braids. This acts as a lubricant and tends to insure easy drawing in.

Greases and oils should never be used as lubricants when pulling in conductors. Materials of this character act chemically on the rubber insulation and cause it to soften rapidly and lose its insulating properties. The practice of pulling a greased cloth through a conduit run prior to the insertion of conductors is positively condemned. Numerous cases are on record where oil has been poured into ducts for lubrication. Where this has been done, insulation failures, grounds and burnouts invariably result.

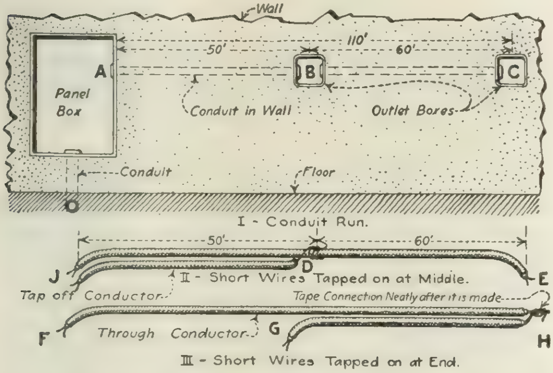


FIG. 5. METHODS OF TAPPING ON A SHORT WIRE FOR DRAWING INTO CONDUIT

Paraffin has been used for a lubricant where conductors are being pulled in, but apparently its use is not frequent. In using paraffin, a block of it is rubbed against the conductors as they are drawn into the tube. Paraffin is a splendid insulator and is therefore unobjectionable from this standpoint. However, it appears to the writer that it is probable that an excess of paraffin on the braids of conductors within the conduit runs would be liable to cause the braids to adhere to the inner walls of the tube and might thereby prevent withdrawal.

In pulling in an easy run, the fishing wire having been fastened to the conductors, the latter may now be drawn into the conduit. If a ribbon fishing wire is to be used for pulling in, it should follow that the conductors are small and the pull light. A heavy pull should not be attempted with a ribbon fish wire as a pulling-in line, as the wire is liable to be rendered unfit for further service. If a greater force is required than can be exerted by two men each having hold of the wire and walking along the floor, either a galvanized-steel wire, a braided rope or a chain pulling-in line should be used.

Conductors can be drawn in by pushing and pulling simultaneously. While one or two men are pulling the conductors out at the far end of the run, another man can accelerate progress by pushing or feeding the wires into the other. This man can prevent the formation of kinks and can "ease" the wire over the abrupt edge at the outlet.

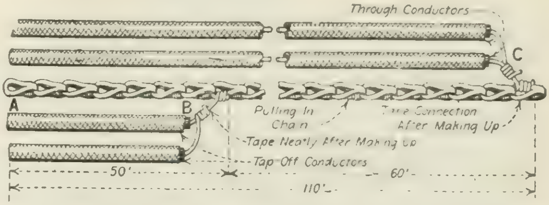


FIG. 6. TAP-OFF AND THROUGH CONDUCTORS ATTACHED TO PULL-IN CHAIN

It is difficult to obtain a secure grip with the hands on ribbon fishing wire when pulling in; hence it is almost impossible to pull by this method against any considerable strain. Wiremen sometimes bend the bight of the wire around a stick or otherwise distort it to enable them to gain a hold, but this is bad practice. The kinks so formed in the ribbon fish wire can never be removed entirely, although they may be apparently removed. A ribbon thus punished will always give trouble when used for future fishing.

A parallel-jaw grip, or come-along, Fig. 3, can be used in gripping fish wires. If the surfaces of the edges of the two parallel plates, *P* and *P*, between which the wire is clamped are smooth, they will not mar the ribbon. The fact that grips of this type are used successfully for pulling up hard-drawn copper aërial line wire is sufficient recommendation. A spring (not shown in the illustration) with which the grip is equipped, tends to clamp it lightly on the wire, preventing it from falling off. When a tensile stress is applied at the loop *L*, the clamping effect is intensified. Three sizes of this clamp are manufactured. Each respectively is capable of accommodating a wire of small cross-section

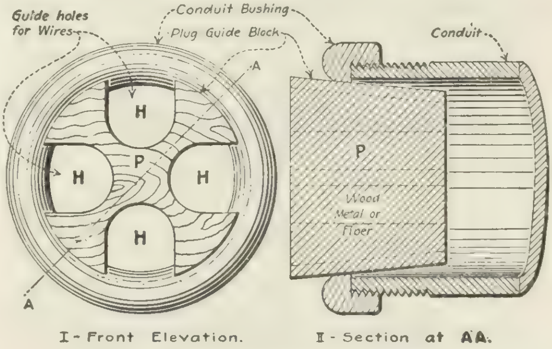


FIG. 7. PLUG-TYPE GUIDE BLOCK

to a No. 6, No. 0 or No. 000. In using the grip, it is clamped on the wire to be pulled and a short rope is tied into the loop *L*. The rope provides a good hold for the wiremen's hands.

Tackle blocks provide the usual method of obtaining the desired force for pulling in a heavy run. One block of the set is provided with a loop and the other with a hook. The block with the loop is made fast to some substantial object, and the hook of the other block is engaged with the pulling-in line.

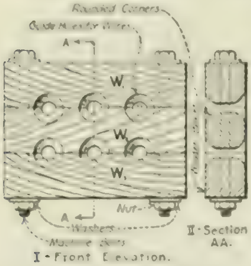


FIG. 8. SPLIT-TYPE GUIDE BLOCK

When drawing in tap-off conductors with through conductors they should all be pulled in together. Tap-off conductors are short conductors that terminate at any outlet nearer to the pulling-in location than the most distant outlet on the conduit run; through conductors are those which extend entirely through the conduit run from the pulling-in location to the farthest outlet. It is practically impossible to first pull into a conduit a portion of the conductors that are to be installed therein and then refish the tube and draw in the remainder. If four conductors are to be drawn in, all four should be pulled through together until the tap-off outlet where the shorter wires are to terminate is reached. Then the short ones should be held stationary while the longer ones are drawn on through to their destinations. Consider the example of Fig. 5. Assume that one conductor is to be drawn from *A* to *C* and another from *A* to *B*. The preferable method would be to draw in the two wires arranged as shown at *III*, being spliced together at *H* for pulling in. When the pair has been drawn from *A* as far as *B*, *GH* would be disconnected and held stationary, but *FH* would be pulled on through to *C*. Difficulty may be experienced if an endeavor is made to fasten the short tap-off wire around the insulation of the other wire, as at *D*. The attachment is liable to fail—slip and jam in the conduit and cut into the insulation.

In pulling in tap-off and through conductors with a chain pulling-in line they can be attached to the line as proposed in Fig. 6. The through conductors are assumed to be 110 ft. long, are attached to the chain pulling-in line at *C*. The tap-off conductors, assumed to be 50 ft. long, are fastened to the pulling-in line at *B*. This method is feasible with a chain pulling-in line because of the ease with which the conductors to be drawn in may be attached at any location.

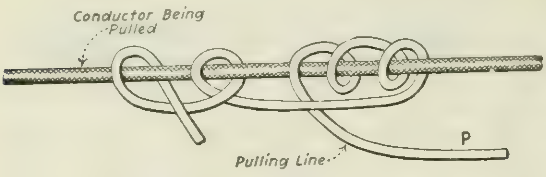


FIG. 9. ROLLING HITCH FOR PULLING WIRE

Always where a number of conductors are being drawn into the same conduit they should be free from kinks and should be guided into the tube so that they will not twist about one another and foul. Unless these precautions are observed, the conductors may twist into a cable within the tube and bind.

Guide blocks may be used to insure that a number of conductors that are to be pulled in will enter the conduit parallel to one another and prevent the twisting which may render it difficult or impossible to pull in or withdraw the conductors. Where guide blocks are not available, the wires may be guided through the fingers of the man who is feeding. The guide block *P* detailed in Fig. 7 is a plug, ordinarily of wood or fiber, tapered to fit snugly the outlet bushing. Parallel slots *H* guide the conductors into the tube. Where the expected service will justify the expense, this plug *P* may be of metal, machined smooth. Another form is portrayed in Fig. 8. It consists of three strips of wood, W_1, W_2 and W_3, clamped together with two machine bolts. The conductors are guided by the holes *H*.

Where possible it is best to pull from the distribution cabinet toward the lamp, switch or motor outlets. Where this procedure is followed, the coils of wire are all fed from one location, which minimizes unnecessary handling. Furthermore, when all the wire that is being fed in is concentrated at one location, it may be watched more readily.

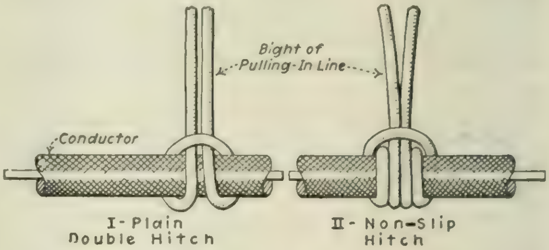


FIG. 10. NONSLIP HITCH FOR PULLING WIRE

Conductor ends should be left extending from the outlets to permit of splicing, making up and tapping on through wires. At switch and fixture outlets a free end, six inches long, is ordinarily sufficient where the conductors are small, but where they are large, a greater length may be necessary. At the panel boxes or switchboards, the proper length for the extending free end will be determined by conditions. The conductor must be long enough to reach the switch or cutout terminals to which it is to be connected. After the conductors have been pulled in, the next steps toward the completion of the installation are connecting and soldering.

In tying a rope-pull line direct to heavy conductors, such as might be the case if the latter were being pulled out of a conduit, a knot of any one of several types may be used. In Fig. 9 is given the "rolling hitch," which will grip firmly into the insulation on a large conductor. All the turns should lie close together and be pulled up tight before the pulling stress is imposed. Half-hitches made around the conductor at the pulling end *P* of the knot will increase its gripping power. Another knot, which has been called a "non-slip-hitch," is reproduced in Fig. 10 at *II*, in which a sling is used. To tie the knot, pass the bight of the sling around the conductor and pass the sling through the bight as shown at *I*, making a plain double hitch. Now pass the bight around the conductor again and slip the end of the sling through the bight. Pull the strands tight and the resulting knot will appear as at *II*. This hitch is very easily tied and is extremely effective.

Ammonia Required for New Refrigerating Plant

By J. Kilian

The Parktown Packing Co. was planning an addition to the packing house and engaged the well-known packing-house architects, Binks & Jones, to make the layout and specification. When work was fairly under way, Mr. Brown, the president of the packing company, called Jimmy, his chief, into the office and delegated him to run up to Chicago to look over the plans as laid out by the engineers and see if he had anything to suggest as to the mechanical layout. Jimmy, although he cannot boast of having a college degree, has had a world of practical experience around packing houses and Mr. Brown has full confidence in him.

After arriving in Chicago and checking in at the La Salle, Jimmy hied himself over to Binks & Jones' office. He went over the layout with them and made a number of suggestions which were duly taken. "Why do you specify that the contractor shall charge the plant with 2000 lb. of ammonia?" he asked of George, one of the four M.E.'s in the drawing room. "Why, I figured it," said George. "I don't think it is possible to figure the exact amount to be furnished," said Jimmy, "and believe you ought to specify that the 'required amount' be furnished, as no one can tell in advance exactly what is necessary." "Oh, but I have a rule that works O. K. every time," said George. "So have I," said Ed, another one of the designers, "and mine is right every time, too."

This brought about a general discussion of the matter, and it developed that each of the four engineers in the office had his own method of estimating the quantity of ammonia required. As Jimmy was a little weak on this subject, he determined then and there to get the data. He bethought himself of the "seven-centers" in his pocket, and in a few minutes, under the soothing influence of the smokes, he had secured the four methods, which were as follows:

George's method:

1/7 lb. per running foot of 1¼-in. ammonia evaporating pipe.

1/5 lb. per running foot of 2-in. ammonia evaporating pipe.

¼ lb. per running foot of 1¼-in. ammonia pipe, flooded system.

25 lb. per 12-pipe high-standard double-pipe ammonia condenser, 2-in. and 1¼-in. pipe and proportionately more or less for higher or lower condensers.

50 lb. per coil of atmospheric ammonia condenser and proportionately less for lower condensers. Pipe, 2 in.

Liquid receivers to be half full, which means:

For 8-in. diameter receiver, 6.9 lb. per foot length of receiver.

For 10-in. diameter receiver, 10.0 lb. per foot length of receiver.

For 12-in. diameter receiver, 15.0 lb. per foot length of receiver.

For 16-in. diameter receiver, 27.5 lb. per foot length of receiver.

For 20-in. diameter receiver, 43.75 lb. per foot length of receiver.

For double-pipe brine coolers, standard-length, 3-in. and 2-in. pipe:

4 pipes high, 27 lb. per coil for evaporative type, 67 lb. for flooded type.

6 pipes high, 40 lb. per coil for evaporative type, 100 lb. for flooded type.

8 pipes high, 53 lb. per coil for evaporative type, 133 lb. for flooded type.

10 pipes high, 67 lb. per coil for evaporative type, 167 lb. for flooded type.

12 pipes high, 80 lb. per coil for evaporative type, 200 lb. for flooded type.

14 pipes high, 93 lb. per coil for evaporative type, 233 lb. for flooded type.

16 pipes high, 107 lb. per coil for evaporative type, 267 lb. for flooded type.

Ed's method:

1¼-in. ammonia evaporating pipe:

For short coils up to 300 ft. long, 7 running feet of pipe per 1 lb. of ammonia.

For long coils above 300 ft. long, 8 running feet of pipe per 1 lb. of ammonia.

For flooded coils, ¼ lb. per foot of pipe.

2-in. ammonia evaporating pipe:

For short coils up to 200 ft. long, 3 running feet of pipe per 1 lb. of ammonia.

For long coils above 200 ft. long, 5 running feet of pipe per 1 lb. of ammonia.

For coils to go into air-conditioning apparatus, coils to be figured about one-half full.

For flooded coils, 0.7 lb. per foot of pipe.

15 lb. per coil of standard-length double-pipe ammonia condenser, 12 pipes high, 1¼-in. and 2-in. pipe.

60 lb. per coil of standard length atmospheric ammonia condenser, 24 pipes high, 2-in. pipe.

100 lb. to 200 lb. for the liquid receiver, depending on the total amount in the system and size of receiver; 50 lb. or less for receivers of small plants.

Frank's method:

For ammonia exaporating system figure 1 lb. of ammonia per 4 to 6 ft. of 2-in. pipe, and 7 to 15 ft. of 1¼-in. pipe, for fairly high temperature work; the quantity to be increased for low temperature work.

For flooded system use ¼ lb. of ammonia per running foot of 1¼-in. pipe and 0.9 lb. per running foot of 2-in. pipe.

Ammonia condenser not considered.

Liquid receiver to be figured half full.

For shell and tube brine coolers figure two-thirds of net volume, allowing for the tubes. Figure 37 lb. of ammonia per cubic foot.

Bill's method:

Ice tanks of 15 tons to 25 tons capacity, 1/7 lb. per foot of 1¼-in. pipe.

Ice tanks with coils of flooded type, ¼ lb. per foot of 1¼-in. pipe.

Evaporating pipe in rooms, 6½ to 7 ft. of 1¼-in. pipe per 1 lb. of ammonia.

Evaporating pipe in rooms, 4 to 5 ft. of 2-in. pipe per 1 lb. of ammonia.

Ammonia condenser not to be considered.

Liquid receiver to be about one-third full.

For standard shell and coil-type brine coolers, as follows:

Tons	Quantity, Lb.	Tons	Quantity, Lb.	Tons	Quantity, Lb.	Tons	Quantity Lb.
1	20	8	48	25	235	65	590
2	22	10	63	27½	240	75	700
3	29	12	70	30	275	100	830
4	35	15	80	40	350	125	1300
6	45	20	205	50	410	150	1600

Operation at Holtwood

HANDLING ICE SITUATIONS

By
Charles H. Bromley

The articles on Holtwood operating features would not be complete without a description of the successful handling of ice difficulties at the plant. Ice is the most unmanageable trouble maker in a hydro-electric plant. It can be compared with badly clinkering coal in a steam plant, but it is worse than the worst coal under the boilers. The steam man knows that some clinkers may reduce the boiler output and in time may burn up grates; others, if not properly handled, may fill up the air openings of the grates so badly that the fuel bed will produce only a small portion of the effective heat that it is supposed to give off to the heating surface of the boilers. In the hydro-electric plant, however, it is easily possible that a certain kind of ice may shut down the entire station by preventing water from entering the turbine passages.

JUST as there are different kinds of bad coal, so there are different kinds of trouble-making ice in the river water. It would be well to define and name them: Floating cake ice, frazil ice, and anchor ice.

Floating cake ice is well known to everybody who ever saw one of our larger streams in the moderate or northern climates carry off millions of tons of up-river ice down to the lower reaches. This kind of ice passes every year to the Holtwood plant, but has never interfered with its operation.

Frazil ice is formed during cold weather and high wind in the absence of a protecting layer of ice on the river or "lake." The water becomes chilled a little below freezing temperature, then needles of ice appear, and these, by sticking to racks, gates and turbine parts, choke off the water supply to the turbine or prevent operation of the turbine gates. The frazil ice lasts until a rise in temperature comes, as with the rising high of the sun, or decrease in velocity of cold wind, or rise in its temperature. Frazil ice does not occur when the lake is entirely frozen over. However, a few open places in the lake are sufficient to cause trouble at the power house.

Anchor ice is formed when there is no surface ice, or only a very thin coating, especially on clear, cold nights. This ice forms on the bed of the river and with a rise in temperature, usually a little after sunrise, becomes detached in huge masses of slush. Trouble arises so quickly that preparations are made for it long in advance, a close watch being kept for those conditions that produce such ice. The gatehouse water temperature is watched very closely as it approaches the freezing point. A gas-bulb recording thermometer is used, although it is not wholly relied upon, and is checked by a spirit thermometer submerged in a test bucket. This is particularly true when the water closely approaches the temperature at which frazil ice is likely to form.

Test Chain Used as Frazil Ice Indicator—When frazil ice threatens, half-hourly examinations of a chain, kept in the gagehouse, immersed in the flowing water of the forebay, are made. The ice needles attach themselves to the chain when they begin to form. The chain is tied to a rope, and it is interesting to know that ice crystals will adhere to the "whiskers" of the frayed end of the rope before any crystals will adhere to the chain. In other words, the presence of frazil ice will be revealed by the frayed rope quite awhile before crystals can be seen on the chain. This is the experience at Holtwood.

It was for long thought that high river flow—that is, considerably above the station demand, was not a condition when frazil ice could form owing to the flow of comparatively warm water from small streams and surfaces. More recent observations, however, during river stages more than double the power-house draft, have contradicted this theory

Another Warning—On days when frazil ice threatens, a 50-hp. turbine-driven, hand-control pump is operated continuously at a fixed gate opening, and its speed frequently observed. The inlet to the penstock of this turbine is protected by a closely spaced screen area, which has a tendency to clog up long before frazil ice sticks to the wider spaced screen bars of the main units. Decrease in speed otherwise not explainable by external load conditions will be one of the first indications of imminent ice troubles, sometimes accompanied by a rumbling noise in the turbine casing. Trouble of this kind usually comes in the morning preceding the peak load.

Handling of the Screens—From Nov. 15 of each year until Mar. 15, during the "open" winter season—that is, when the lake is not completely frozen over—it is the practice to run without some of the screens in the turbine intakes. Should the screens be left in, they would become clogged with ice and shut down the plant. However, precaution must be taken to care for the trash that is likely to come down with a freshet at almost any time.

Each intake has five screens in it. The uppermost screen is removed entirely as it is usually above the water level. The second and third screens are linked together by pieces of steel cable and are drawn up out of the water and suspended in their guides by blocking on the gatehouse floor in such a manner that they can be quickly lowered in case an unusual amount of trash should appear in the water. They are tied together so they can be handled quickly. The fourth and fifth screens are left in place at the bottom of the intake.

There are so many screens to be handled that if facilities for rapid handling were not provided, the station output might be materially reduced before the screens could be removed, as the ice accumulates very rapidly. Furthermore, should the screens become clogged and the water level in the pits not watched closely, the difference in water level in front and in back of the screens is liable to crush them. The present practice of handling the screens is considered by the Holtwood operating men to be quite an improvement over the system of a few years ago, when the screens on three intakes were left in place up to the time of imminent ice trouble, while the screens of the fourth intake were removed and its headgate closed. The raising of the fourth headgate insured at once about 50 per cent. turbine capacity, even if all the screens of the other intakes were clogged. The removal of the upper rows of screens on the other intakes, during the frazil-ice run, then increased gradually the capacity of the unit, but it was a slow procedure because of the large number of screens that had to be handled.

Before the winter season the area in front of the racks is cleaned of all débris by divers, as submerged trash may enter the intakes after the removal of the screens. When ground or anchor ice comes, this is particularly the case, because the anchor ice tends to pick up and float water-logged ties, trees, etc., which lie on the river bed. This is a time when the operator must exercise unusual vigilance and listen for unusual noises in the turbine and take proper precautions in case of fouling of the turbine-gate rigging.

During the winter the gatehouse is maintained as warm as possible by the heated air from the generator room. Particular care about this is taken during times when ice formation is likely to occur.

Precautions with Exciters—During the open winter season one exciter has three of its screens removed. Ordinarily, only the motor-driven exciter and the turbine that has the intake protected by screens are used. The storage battery for exciter service is always maintained fully charged.

A dinkey boiler has its fire going all winter, except when the river is completely frozen from shore to shore. A steam-hose connection from boiler to a header, with permanent connections to each turbine, is provided, so that live steam may be available for thawing ice in the wheelpits of exciters or main units.

Imminent Ice Trouble on Main Unit—As soon as frazil ice is noticed, customers are notified to be prepared for taking over a portion of their loads on the steam plants. The Holtwood station output is deliberately reduced by the capacity of one turbine unit, as a precautionary measure, and the other units are operated at slightly reduced gate opening, so that the flow of water through the turbine vanes is as nearly tangential as possible. It has been found that the ice adheres to the vanes less rapidly when the water does not impinge directly on them. This means that the station output is reduced to about 70 per cent. of normal.

The headgates on the unit out of service are lowered and the wheelpit is heated with steam from the dinkey boiler. This unit is held in reserve.

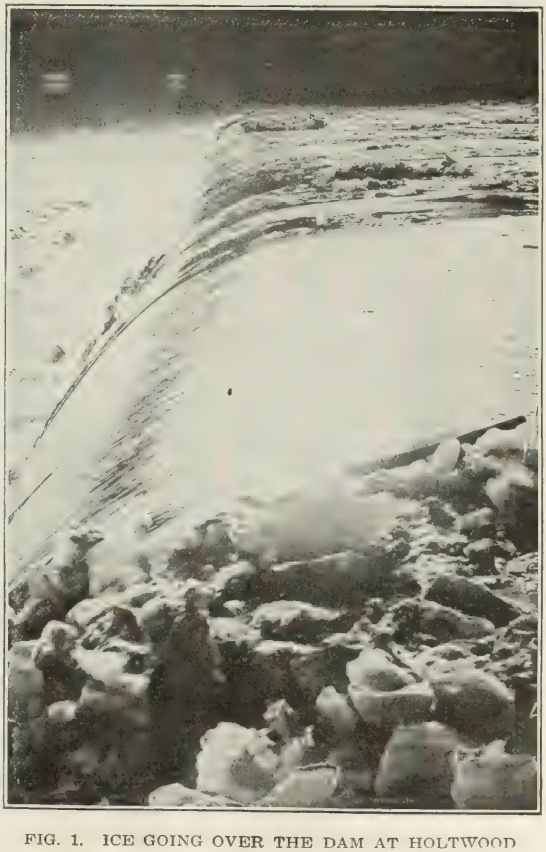


FIG. 1. ICE GOING OVER THE DAM AT HOLTWOOD

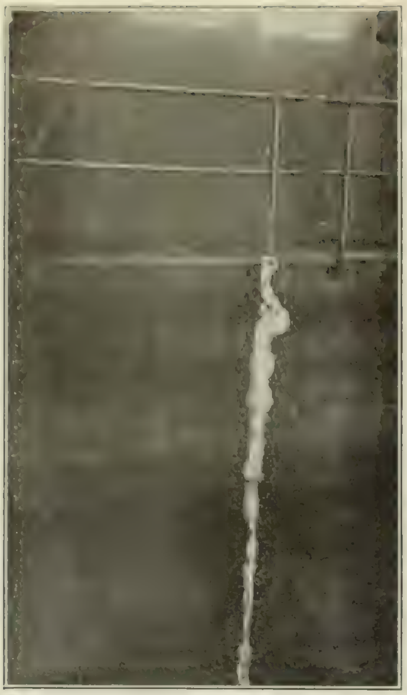


FIG. 2. FRAZIL ICE ADHERING TO CHAIN DROPPED IN WATER IN FRONT OF THE SCREENS

The units in service will gradually accumulate ice; those nearest the river more rapidly than the others. The gate-opening mechanism is kept moving slowly all the time, as this greatly helps to keep the ice from freezing fast to the mechanism. The water level in the pit is watched constantly on the pressure gages on the main floor, so that cold air cannot enter the wheelpit and accelerate the formation of frazil ice around the gate rigging. As soon as the output of any unit is materially affected, it is taken out of service and replaced by the reserve unit.

Evidence of the turbine passages filling with ice is given by the turbine carrying less than normal load for the particular gate opening observed at the time. The operator keeps in touch with this through the floorman, so he can quickly throw in the spare unit when necessary. He must avoid keeping a unit in so long a time that the ice freezes thickly in the passages, because of the relatively longer time required to thaw a heavy coat of ice.

Clearing Main Unit of Ice—On the unit that shows reduction of output, the headgates are lowered and the pit drained. A quick inspection of the wheel is made if load conditions permit. Live steam is then admitted to the wheel pit. The purpose is to heat the ice adhering to parts of the turbine to the point where it loses its adhesiveness. In about twenty-five or thirty minutes the ice is sufficiently loose, so that it washes out when the machine is put back on load and the gates moved a few times. Operation is resumed and continued until the parts again collect sufficient ice to require steaming. Each unit as it clogs up is taken out of service and steamed.

Treating Ice on Exciter Wheels—The motor-driven exciter is loaded fully, so that the waterwheel exciter carries as little load as possible. The less load carried on the turbine the slower will be the accumulation of ice. Direct-current driven station auxiliaries are transferred to alternating-current driven outfits as far as practicable. The other exciter pit is drained, heated by steam and held in reserve.

When the operating exciter becomes clogged with ice, it is replaced by the reserve exciter, the headgate lowered, and steam admitted until the ice has thawed sufficiently to be washed out.

Organization of Crew—At the first indication of ice trouble, all concerned are called out by means of a special whistle and by telephone. The operator solely is held responsible for diagnosis of conditions productive of ice. Definite duties are assigned to each man, provision being made for one or more substitutes in case some men are not available just at that time. The detailed assignment of duties, which follows, gives a good idea of the things to be looked after in the station during a frazil-ice run.

HOLTWOOD ORDER NO. 818

To: Operators and Floormen.
Effective: Nov. 26, 1918.
Superseding: Holtwood Order No. 754 Issued Nov. 15, 1917.
Subject: Emergency Organization and Duties of Maintenance Men in Case of Frazil-Ice Trouble.

During threatened frazil-ice trouble the operator will call out everybody concerned in the operation of the station. Operators shall use the telephone for notifying all those named below, so that they can report to the power house at the earliest possible moment to assist in operation of the station during the threatened trouble. Operators will act in accordance with Permanent Instructions, Section No. 20, *Abnormal Electrical Operation—Ice Trouble.*

In case of the absence of the first man named, the man named immediately below, in parenthesis, shall act.

Stabley .... In charge.
(Oppenheimer)

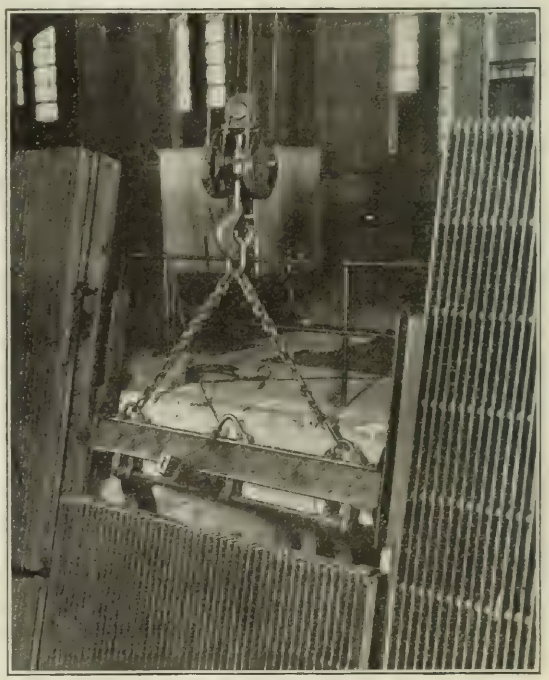


FIG. 3. TACKLE FOR LIFTING SCREENS

OPPENHEIMER (Morgan) (Lowy) (R. D. Shaub)	Keep in touch with station capacity, recording same at frequent intervals, predicting same when necessary and keeping operators informed on these points. Record time of events for purpose of report.
R. D. SHAUB (Nichols)	Assist in operation of benchboard, see that turbine vanes are kept moving during the actual run of the ice.
CHRISTIANSEN & MEN (O'Neill)	Attend to dinkey. Remove exciter screens. Run gatehouse crane—W. Wells. Keep forebay free of all floating timber while screens are out.
KEATING (1st pumpman on watch)	Attend to tunnel steam. Make and maintain emergency steam connections. See that supplies of miscellaneous fittings, pipes, valves, hose, etc., are on hand for emergencies.
BALLANTYNE (Kauffman) (Wells)	Look after lighting. See that dinkey has sufficient light. See that men working in wheelpits are provided with any additional lights needed. Provide operator for the searchlight and maintain same.
O'NEILL (Abbott)	Attend to opening and closing of wheelpits. Make examination of ice conditions in wheelpits, noting the time of steam on and steam off and method of application, and make written report on same.
LOWY (R. D. Shaub)	Note meteorological conditions. Note amount of ice in forebay, around log booms and on pond, making sketches of same. Note water temperatures and characteristics of ice formation on test chains, screens, dam and any other points of interest or of value as research data. Notify operator of any anticipated sudden and marked drop in head due to ice hanging on dam clearing off.

Signed,

T. C. STABLEY,
Chief Operator.

Service Record of Frazil-Ice Occurrences—The foregoing methods of handling ice at the Holtwood station are the result of many years of experience and experiments. During the first few years of the operation several service disturbances occurred, due to the screens, turbines or exciters becoming clogged with frazil ice. On the occasion of the first frazil-ice run in January, 1912, the installation of the motor-driven exciter and of the large storage battery was not yet completed, resulting at that time in the only total interruption of service experienced at the plant due to frazil ice.

In most plants with higher head the problem is considerably less difficult than at Holtwood. There are very few stations where, if the screens are removed, the ice will not go through the turbines without clogging them. A probable reason for this is that in most stations the turbines are set in iron casings exposed to room temperature; at Holtwood the turbines do not have this advantage. A small fraction of a degree above the freezing point seems to be sufficient to prevent the ice from adhering to the turbine parts.

The difficulty is that at the Holtwood Station the double runner turbine units, Nos. 1 to 7, are entirely submerged in a large wheelpit without any opportunity for absorbing heat from the warmer parts of the building. The single runner unit No. 8 has so far been practically immune against frazil-ice formation, probably owing to the better exposure of some of the turbine parts to the warm air of the generator room. The quantity of water handled by the turbine is so large that it is impractical to heat it by steam or electricity, even to that small fraction of a degree which is necessary to prevent the frazil ice from adhering. The energy required to heat the water $\frac{1}{10}$ deg. C. would equal about one-third the output of the station.

Many different methods of screen handling, turbine heating, loading of units and ice detection have been tried and the practice outlined has resulted. While an ordinary ice run lasts but a few hours, usually not more than eight or ten, there is on record a case that lasted thirty-six hours, and this was negotiated without any disturbance to customers. Frazil ice seemed an almost insurmountable difficulty at first, but by the system that has been developed at the plant it is not likely that any

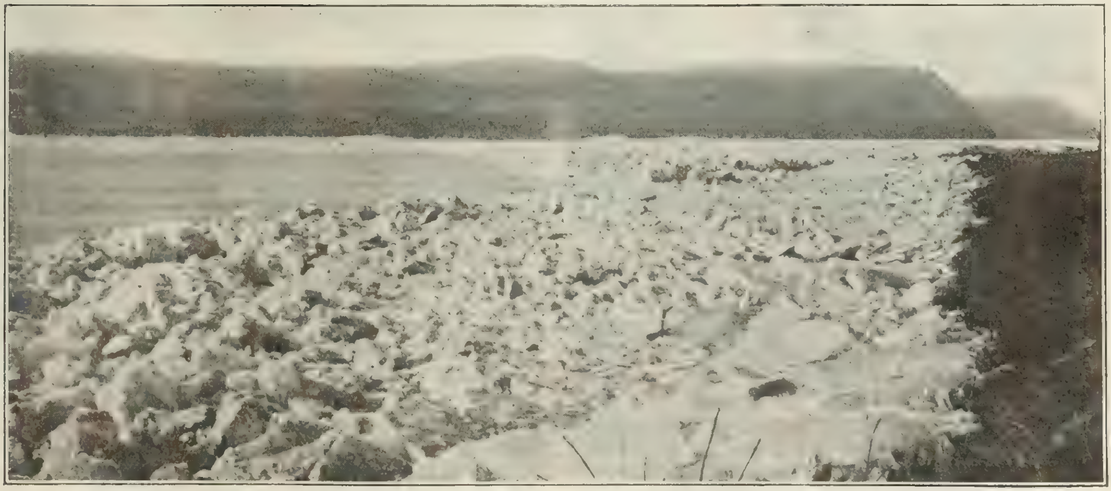


FIG. 4. ICE JAM IN THE SUSQUEHANNA RIVER A LITTLE ABOVE HOLTWOOD

ice run, however severe, will interfere with service to the customers.

Following is a record of all the frazil-ice occurrences since the plant was put in operation (October, 1910) and their effects on the service:

Date	Ice Noted on Test Chain	50 Hp Turbine Pump Affected	Turbines Affected	Disturbance to Service
Jan 5, 1912	Not in use	Not in use	Screens and exciters closed without warning	Total interruption
Feb 14, 1914	Not in use	Not in use	Portion of screens clogged on main units	Frequency and voltage disturbance
Jan 30, 1915	3 55 a m	3 55 a m	8 00 a m	None
Jan 15, 1916	3 00 a m	4 30 a m	5 45 a m	None
Jan 17, 1916	6 30 a m	6 30 a m	8 25 a m	None
Feb 10, 1916 (Anchor Ice)	5 55 a m	5 50 a m	Not affected	None
Mar 16, 1916	5 45 a m	Not affected	Not affected	None
Dec 16, 1916	7:00 a.m	Not affected	Not affected	None
Jan 5, 1919	5 40 a m	5 45 a m	8 18 a m	None
Jan 10, 1919	4 14 a m	4 20 a m	Not affected	None

To those who desire further information on ice, its formation and methods of handling it, particularly in hydro-electric plants, the book, "Ice Formation," by Barnes, is recommended.

Auxiliary Source of Gland-Sealing Water

By C. H. Sonntag

The amount of water in a spray cooling pond operated in connection with a jet condenser will gradually increase, excepting perhaps in the very hottest and driest wheather, because the water of condensaton, which is mixed with the circulating water, more than makes up for the loss by evaporation. If the pond is allowed to overflow, the water in it will, because of the continuous dilution by condensed steam, become very soft, even if the pond was originally filled with hard water. Such a pond then offers a limited supply of soft water, which may be used for boiler feeding or other purposes.

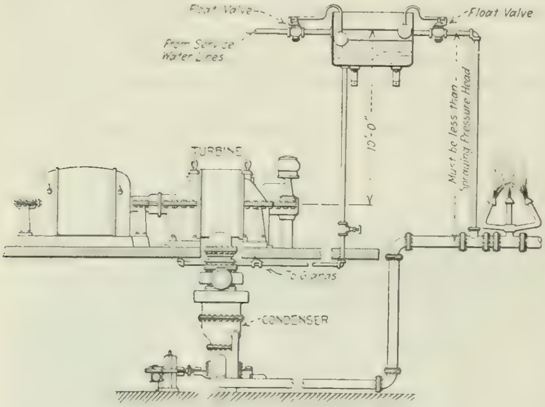


FIG. 1. PIPING OF GLAND-WATER SYSTEM SHOWING RESERVE SUPPLY TANK

In a turbo-generator station using a certain type of machine, there is need for soft water to seal the turbine glands. The builders of this particular machine specify that sealing water shall be furnished at a pressure equivalent to a 10-ft. head. If the relative levels of the spray nozzles and turbine permit, the spraying pressure may be used to supply the glands directly. In our plant this condition exists, but we have installed a supply tank as shown in Fig. 1, which gives a reserve supply of soft water. The float valve keeps the tank full and at the same time prevents waste.

Although we have not done it, the tank could be fitted with another float valve at a lower level, which would admit water from the general service lines in case the supply of soft water should fail for any reason. The tank could also be fitted with a low-water alarm of any desired type, as a bell or red light. The use of spray-pond water in this way does not really remove any water from the pond, for practically all the loss from the glands is drawn into the turbine, where it mixes with the condensed steam and returns to the pond.

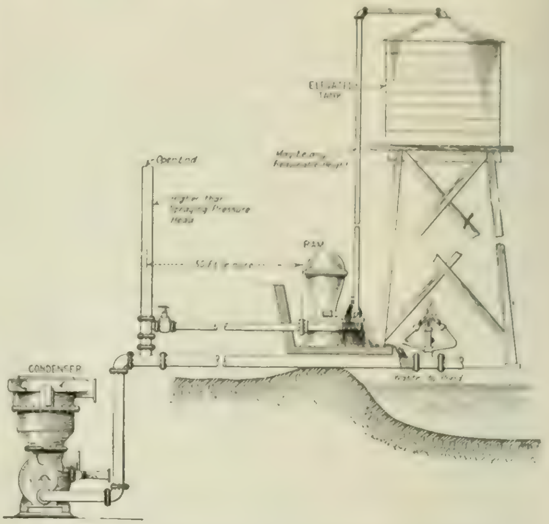


FIG. 2. RAM FOR SUPPLYING GLAND WATER, CONNECTED WITH STANDPIPE

When we installed this system, our turbine glands were badly scaled up and we were about ready to open the machine and clean them. Since using soft water, their condition has steadily improved, and we see no reason why we should clean them, as the soft water seems to be gradually dissolving the scale which was formerly present.

If the spraying pressure is not sufficient to supply the glands directly, a hydraulic ram may be used instead of a steam pump to pump water to the supply tank. It would get its working head from the spray pressure and so utilize energy already available. Its waste should return to the spray pond, so that no water would be lost from the system.

In our case we have avoided the use of a steam pump by installing a hydraulic ram, the arrangement being as shown in Fig. 2. The ram operates with energy already available, and it uses so little water that it has no noticeable influence on the spraying. The standpipe is necessary to give free vent to the air that is mixed with the water from the condenser, so that the pipe feeding the ram shall be filled with solid water. The ram is set on the intake well of the pond, and in a sheet-iron pan in such a way that its waste water all returns to the pond. Hence no water is taken from the circulating system excepting that actually pumped into the tank.

Circulation in Water-tube Boilers

By A. Bement

IN THE days of low settings and insufficient flame travel the usual three-pass vertical baffling resulted in smoke production and loss of heat due to incomplete combustion. As a remedy the use of a fire-tile roof over the furnace, fitted to and carried by the lower row of tubes of the boiler, proved to be satisfactory. The application of the tile roof to the type of boiler shown in Fig. 1 was made in a considerable number of cases in which superheaters were installed. As it was not considered desirable to make changes in the location of the superheater or the gas outlet, the manner of gas travel indicated by the arrow was adopted. The result of this arrangement was an increased furnace efficiency. The boiler efficiency was reduced, but not enough to overcome the furnace gain. The degree of superheating, however, was reduced a considerable amount below that obtained with the three-pass vertical baffling where the gases come in contact with the superheater after passing once directly across the tube surface, instead of the longer horizontal bottom and considerable vertical front travel, thus arriving at the superheater at a lower temperature.

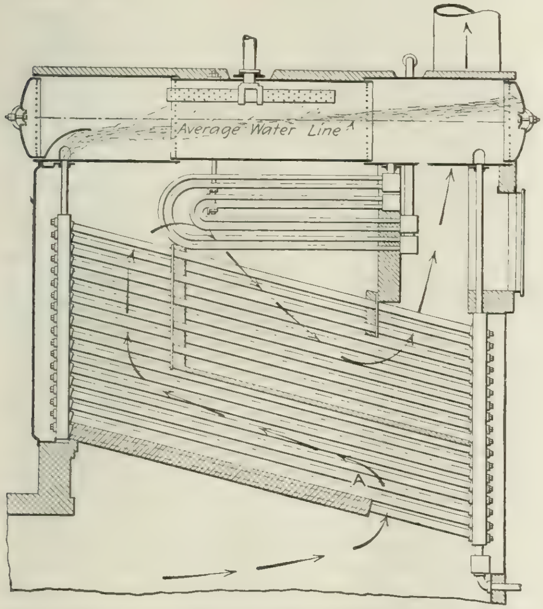


FIG. 1. HORIZONTAL DRUM AND SYSTEM OF BAFFLING THAT CAUSED TOP SURFACES OF TUBES TO DETERIORATE

In other respects no further unsatisfactory feature was observed until boilers so fitted had been in service a few years. Failure of the tubes in the second and third rows then occurred at the point marked *A*. These failures occurred on the top surface of the tubes, and when removed, they were found at the point of failure to have been reduced to a thickness of about $\frac{1}{32}$ in. This thin portion extended for about two feet in the length of the tube, all other parts being apparently of the original thickness; even the bottom portion just below the thin part showed no evidence of reduction.

A number of theories were advanced in explanation. One was that the gases, after their rush from the furnace, rebounded, taking a downward course and impinging on the top of the tubes at the point of failure, and that the ashes and cinder they carried reduced the thickness of the metal by erosion. This theory does not account for the fact that the gases take the path of least resistance, in a direct line from the point of inlet to that of outlet and would not diverge from this direct line unless they met with some obstruction. As there is no more obstruction at the point *A* than at any other place on the tube surface of the pass, there would be no special reason for divergence here and the reduction of the tube metal due to erosion would be just as likely to occur on the bottom row as at any other place and would be on the directly exposed bottom of the tube instead of the top. No such reduction of metal occurred on any tubes except at the top surface at *A* of principally the second and third rows.

A much better explanation of these tube failures, and probably the right one, is to be found in the water supply afforded at the point *A*. Such boilers are made up of vertical sections, each composed of fourteen tubes, all of which receive their water supply by way of one vertical pipe leading from the drum above. This pipe is of the same diameter as that of the tubes, so that the feeding tube has only one-fourteenth of the capacity of the section that it supplies, and it is reasonable to question its ability to do so properly. Likewise, the outlet at the front is of the same capacity, although called upon to perform even more work, as it must give exit also to the steam with its greatly increased volume. Doubts as to this construction have existed, particularly for loads above rating, but there has been only limited actual knowledge. A case may be cited, however, that may afford definite proof.

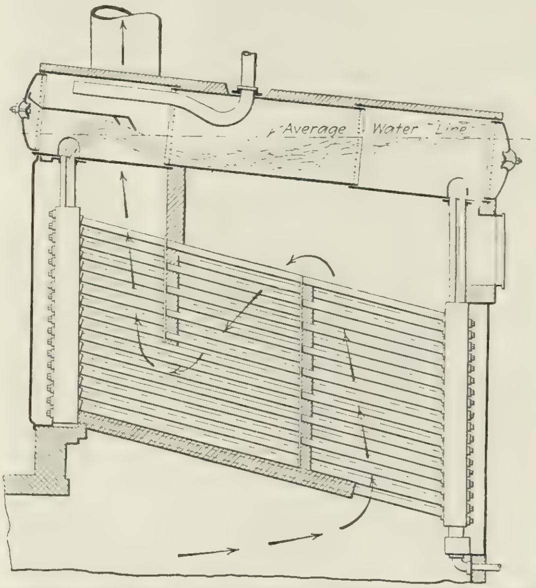


FIG. 2. SHOWING DRUM WITH DOUBLE NIPPLES, IMPROVED BAFFLING AND BETTER SEPARATION OF WATER AND STEAM

A boiler of the type in question. fourteen tubes high and fitted with a tile roof, had operated with perfect satisfaction for a considerable time. The inclosed furnace produced by the presence of the roof caused a high furnace temperature, proportionately destructive to furnace linings, and it was thought that if a portion of the heat could be absorbed from the gases while still in the furnace, the temperature would be so lowered as to extend the life of the brickwork. To this end the roof was removed at a point just above the fire for a distance of 2 ft., the space above being closed by tiles covering the top half of the tubes. The result for as long as the experiment continued was quite satisfactory to furnace linings, but in four or five weeks the bottom row of tubes at the exposed location over the fire had burned through and required renewal. The opening from the furnace at the end of the roof was 5½ ft. The tube exposure was, therefore, 7½ ft.—and the whole tube for 5½ ft. and the bottom half for 2 ft. The tubes were kept as clean as before, so in this respect conditions were equal. This 2-ft. exposure was not subjected to higher temperature than had been the 5½ ft. at the back, because before the exposure over the fire was made, the full temperature was discharged onto the rear length. The conclusion to be drawn is that the water supply was sufficient for a length of 5½ ft., but not for 7½ ft. It is known from experience in steel mills that in certain kinds of billet furnaces, pipes of much greater length than these boiler tubes may be kept quite cool if water is passed through them in sufficient quantity. Although passing through a region of high temperature, the water may discharge so as to feel barely warm to the hand.

Fast Moving Center of Hot Gas

Referring again to Fig. 1, it will be observed that failure occurred a considerable distance from the inlet end of the tube. The arrow drawn through the heating surface indicates the hot center of the moving gas body. Experiment has shown that the flowing body of gas has a center of higher temperature that moves faster than its surrounding envelope, the latter spreading out more and lagging behind in its movement. Therefore, the hot center at location *A* had reached a point on the tubes where the water supply had become depleted to a considerable extent. The gases of course had been cooled before reaching this point, but were still hot enough to cause damage. So a critical point is reached where the temperature is still high enough and the water supply has declined sufficiently to cause damage. The reason why damage appears on the top surface would be due to the water flowing along the bottom of the tube and leaving steam only in contact with the overheated part. As a few years' time was necessary to produce failure, it is probable that damage was caused in many small installments of short periods in duration, when, owing to especially favorable coal, high boiler capacity was developed, resulting both in depleted water supply and unusually high gas temperature accompanied or immediately followed by some oxidation of the red-hot tube surface.

Fig. 2 shows a method of baffling that is adaptable to this type of boiler and will overcome the difficulties described, and do so even with the prevailing degree of water supply furnished by the 1 to 14 ratio; but the matter of circulation or water supply is of first importance in view of the growing demand for enlarged boiler output. In this connection Fig. 2 shows a double set of nipples connecting both front and rear headers with the drum. This scheme doubles the water-supply capacity without involving difficulties of construction or operation. Transversely, the proportions are in no way changed, it being necessary only to increase the depth of the headers and lengthen the junction boxes on the drums enough to take two tubes instead of one.

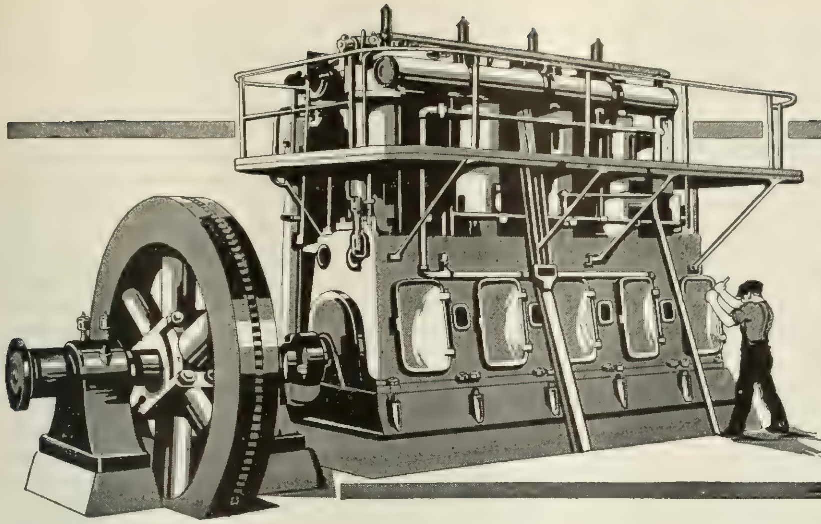
One feature of boilers that has received comparatively limited investigation, but which is nevertheless of much importance, is the separation of the steam from the water. The conclusions here presented are based on much experimental work, a part of which consisted in the use of small boilers provided with glass drums, allowing the visible action to be studied. Fig. 1 shows a typical drum provided with a perforated dry pipe, through which the steam is drawn off. The water in the drum is shown deeper at the rear than in the front, piling up as it flows back. This is characteristic of drum action in all horizontal water-tube boilers. The movement is rapid. Much water rushes up at the front with the steam and flows back as the steam seeks the exit. When driven at high capacity, or when priming occurs, water is carried up with the steam into the dry pipe.

Making Priming Impossible

Fig. 2 shows the drum inclined, sloping back, and provided with a different form of water baffle. Steam is taken from the drum above the baffle at the front by the pipe indicated. The action of this arrangement is to cause the incoming water to be directed back and down in a direction opposite to that at which the steam leaves. The result is complete separation of steam and water under extreme conditions, making priming impossible.

In action, the steam rising to the drum carries with it a large amount of water; in fact, all the water in the boiler is in rapid movement flowing around the cycle. Upon arrival in the steam drum, the bubbles of steam escape and in so doing carry much spray with them. If the space above is sufficient so that the velocity of the rising steam is comparatively low, this spray will drop back, leaving the steam free of water; otherwise it will continue with the steam leaving the boiler. These different actions are illustrated by the two drums shown in Figs. 1 and 2, which also show that the real water lines are not level, the indications of the water glass giving the average level.

As a general practice the water is carried too high in water-tube boilers having drums of the horizontal or sloping type, tending to produce wet steam. As to just how low it may be carried safely in such boilers is not so well understood. When the water drops to the bottom of the gage-glass, it is felt that the danger point has been reached. This is true as far as ability to keep track of the water is concerned, because if out of sight there is no way of knowing where it is. Experiments with the model boiler with the sloping drum showed that the water line as indicated by a specially long gage-glass could be well below the upper tubes at the front, yet circulation continued uninterrupted, with no overheating of the tubes. The rising steam carried the water with it to the drum, whence it flowed back down the slope of the drum to the back nipples. This indicates that if a sloping drum is employed the water line at the front may be carried at the bottom of the drum, thus affording large separating space and insuring great capacity for dry-steam production.



Talks on DIESEL Engines

by L. H. Morrison

XIX—*Egan had been busy and had given little thought to the coming meeting. So, when the evening arrived, he decided to let the men ask questions on matters that they particularly wanted to understand.*

"I INTENDED to take up fuel consumption and tests tonight," said J. R. to the men, "but I haven't had time to get the dope together, so we"ll save that for another time. Instead, I'm going to let you ask whatever pet questions you've been saving up." He turned to the night oiler: "Johnson, what's yours?"

"Hanged if I know, unless it's why an engine smokes."

"Your indecision, Johnson, shows you don't think about your work. A smoky exhaust may be due to one of several things. First, the engine may be overloaded. In this case the fuel pump is delivering more oil than the amount of air—or rather oxygen—in the cylinder can consume. The remedy is to reduce the load.

"Again, it may be due to improper distribution of the fuel charge. By this I mean that only one or two cylinders are receiving any fuel. You can see that in this case the governor will attempt to deliver enough oil to the particular cylinders receiving the fuel to enable the engine speed to be kept up to normal. This overdose of fuel will cause those cylinders to fail to consume it all, so we get a smoky exhaust. The cause of the improper distribution lies either in the fuel pumps or in the oil lines. It may be that the fuel-pump valves leak, allowing the oil from the pump to flow back to the suction line. The remedy is regrinding the fuel valves. It is easy to see if the pump leaks. Just cut out one cylinder at a time. Disconnect the fuel line to the needle valve and see if you get a flow of oil.

"A smoky exhaust may be due to an injection-air pressure too low to break up the oil charge as it passes through the atomizer. The oil then remains in the shape of large drops, and the air can come in contact with only the outside of these, with the result that combustion occurs only on the surface. The exhaust valve opens before the entire drop of oil is consumed, and the particles rush out into the exhaust line still smoking and unconsumed. The remedy is to raise the air pressure.

"Another cause is leaky admission or exhaust valves, which lower the compression temperature in the cylinder until it is too low to cause the fuel to ignite. If you follow instructions about regrinding valves, you won't have this trouble.

"The last cause is one which no engineer should endure—smoking due to excess of lubrication oil. The thing to do is to see that just enough oil is used. Don't think you are playing safe by feeding more than enough.

"Now let's see what Goodhue is laboring over."

"A whole lot of things bother me," admitted the night engineer. "One is why the fuel-cam noses should be adjusted."

"That might be answered by saying it's because they shouldn't, but we'll give a better answer than that. I imagine your question is caused by the fact that we frequently change the cam noses on the old engines.

"From the standpoint of a new engine the noses will not need adjustment within five years of installation. When the engine is tested out at the factory, the noses are properly set. This position is the correct one for practically all fuels. I do not believe the variation in gravity from 20 to 36 deg. Baumé demands any change of the fuel cam. The nose is made of tool steel, hardened, and shows virtually no wear. With the old engines the noses are worn quite a bit. We have experimented with various settings of them. So, Goodhue, the correct answer of why a person should change the cam noses still remains the same—you shouldn't."

"I'd like to put another one, J. R. What is wrong when the engine refuses to start?"

"I will assume that you have the engine set at the proper starting place and your valves in the correct posi-

At the next meeting the Chief will bring to a close his series of informal talks, the subjects being the efficiency of the Diesel engine as compared with other prime movers and the necessity of keeping daily records

tions. The first thing is to note if you have high enough air pressure in your starting tanks. If the engine has a cam relief and starts on low-pressure air, the pressure should be at least 250 lb. per sq.in. If it is of the type in use here, the starting air should be not less than 50 atmospheres, or 750 lb. per sq.in. I don't mean that an engine won't start on 40 atmospheres, but if it's less than 50, you'll likely find that the failure to start is due to the low pressure. If you are running one unit, it's easy to boost up the pressure in the starting bottles."

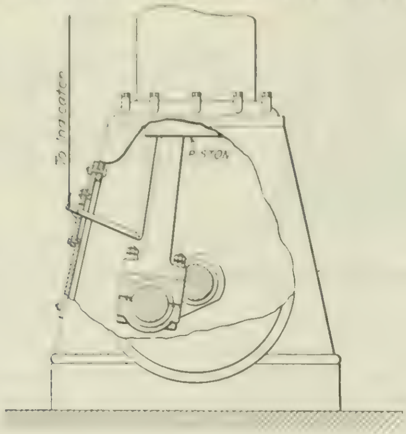


FIG. 1. SWINGING-LEVER INDICATOR RIG

"What are you going to do in a one-engine plant where the compressor is right on the engine?" Goodhue asked, thinking he had put a poser.

"There is a method that may be used in such cases. Go to your favorite soda fountain and get a charged carbonic-acid bottle, or drum, connect it to one of the starting tanks, crack the valve and let the gas into the bottle until the drum pressure drops to about 40 atmospheres. Put hot rags on the gas drum until the evaporation of the liquid CO_2 raises the pressure up to 50 atmospheres. Then open the valve again. Do this until no further application of heat affects the drum pressure. Then use your bottle of CO_2 to start the engine. One thing, don't ever use ether. I know of an oil engine that broke two cylinder heads and one jacket by a wise guy using ether.

"But let's go back to the question of why the engine doesn't start. Maybe your fuel pump is airbound. So disconnect the lines to the fuel valves, set your pump lever to the filling position and keep the fuel lines disconnected until oil begins to flow out. A few engines have a valve mechanism at the needle valve, so it's only necessary to open this overflow valve. Some make use of a bypass valve, which is opened.

"Then we have another reason. If the engine turns over a half revolution, it indicates that either the air starting valves on the starting cylinders are stuck open or the fuel valves on one of the firing cylinders may be wedged open, allowing the high-pressure air to blow into the cylinder.

"Again, the piston rings may leak so much as to lower the compression temperature below the ignition temperature and the engine will not fire the fuel charge. Still another cause, although not very probable, is the admission of the fuel so late as to prevent combustion. "The most improbable reason is incorrect timing of the inlet and exhaust valves.

"Woods seems to have something on his mind. Let's have it."

"Why do some engines use water in the exhaust pipe and then again some don't?"

"The idea of the water drip into the exhaust piping is to cut down the noise. If water is forced into the pipe, it cools the hot gases, reducing the pressure and velocity and eliminating much of the noise. An additional advantage is that the water chills the exhaust gases and sets up a sort of condenser effect. The pressure in the exhaust lines being reduced, the back pressure is less, and the friction horsepower is decreased."

"Chief, why does the drip piping from the exhaust pipe rust away so fast? It looks as if some kind of acid eats it."

"It is some sort of acid, Kelly. The usual fuel oil sold contains some sulphur, which is burned to a gas, sulphur dioxide. When it passes out through the exhaust pipe, it comes in contact with the hot water or water vapor and forms sulphuric acid, which eats iron very rapidly."

"If that is a fact, why doesn't it eat the exhaust pipe?" Kelly demanded.

"It does eat it a slight amount, which isn't apparent, because of the thickness of the pipe. The drip lines are made of steel and are eaten much more rapidly, and, since the metal is comparatively thin, of course, it is soon destroyed."

"J. R., since you are on exhaust pipes, tell me why Diesel engines don't use cement exhaust pots. Our hot-ball engine had one."

"The advantage of a concrete exhaust pot is that it costs much less than a cast-iron pot of the same size. With a two-cycle hot-ball engine you must have a big pot to provide enough dampening to kill the noise. With a Diesel, especially the four-cycle, the exhaust noise is not so great, and a pot of moderate dimensions is ample. With vertical engines the iron pot can be set above the ground, allowing a drain line. With horizontal engines an iron pot is handier, even though it must be set in the ground."

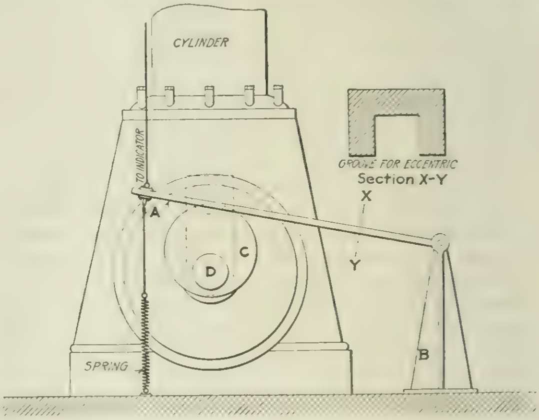


FIG. 2. CAM-MOTION INDICATOR RIG

"If a Diesel don't make much noise, why use a pot that costs money?"

"Of course, there is some noise, Kelly," Egan conceded. "From my viewpoint the pot could be dispensed with if the exhaust pipes were made the proper length. The ways the pot kills the noise are by breaking up the gases as they leave the pipe and by preventing air from rushing into the pipe after the gas has passed out. If the pipe is made the correct length, the first gas charge will be slowed down and just leaving at the moment that the next gas charge is entering the pipe. The space behind the first charge is then occupied by the second charge, and so no air enters the pipe. If the pipe is too long, the passage of the gas is interfered with, raising the exhaust pressure at the engine. I am of the opinion that in most cases no attention is paid to the question of pipe length. Quite often an alteration would lower the back pressure."

"How can you tell which cylinder is missing fire?" the Scotsman queried.

"Simply by removing the plugs from the exhaust elbows, one at a time. Most engines are not provided with these ports, and it's a good idea for the operator to drill $\frac{3}{4}$-in. holes in the exhaust elbows. Personally, I don't see any reason to tap the holes—simply use a brass plug with a handle long enough to keep cool."

"When you hear a pound, how can you tell where it is?"

"Knocks may be divided into two classes—bearing knocks and cylinder knocks. The latter almost without exception are due to some fault of the fuel valve. If the knock is sharp, it is a preignition pound and is caused by the fuel valve opening too far ahead of dead-center. If the pound is rather dull or dead, the fuel valve opens late, and the explosion occurs when the piston is fairly well along on the outward stroke. The knock is caused by the increased pressure forcing the piston pin and the connecting-rod against their brasses.

"Ordinarily, a pound due to worn bearings can be detected at once. To make sure, put the engine on bottom dead-center and pinch upward on the lower edge of the piston with a bar. If it 'jumps' without moving the connecting-rod, you can be certain that the piston-pin bearing is worn. The same test can be used on the big end. Just put a bar under it, when it's on top dead-center, and jump it. As to any wear in the mainshaft bearing, it's seldom it can be detected by any pound.

"Going back to a sharp knock, this could be caused by too high air pressure, which your gage will show. It shouldn't be over 1100 lb. per square inch."

"I've another one, J. R.," Kelly interposed. "You talk about keeping up the compression. How do you know when it's lost?"

"First, you can tell by the way the engine fires. Second, you can use a compression gage. That's a thing I hope to get here. The idea is a small, heavily built tank about 6 in. long by 3 in. in diameter. Inside is arranged a set of baffles. At the top is placed a high-pressure gage. From the bottom a high-pressure pipe with a $\frac{1}{16}$-in. bore leads to the indicator cock. When the cock is opened, the charge enters this little pipe and tank. The pressure builds up to that existing within the cylinder. The baffles prevent the pressure fluctuations from affecting the gage. This will give an approximate value. To be sure the only way is to use an indicator on the engine.

"Our new engines are equipped with an indicator rigging. It's been some months since I used an indicator on the old ones, so for Woods' benefit I'll sketch the rigging. Inside the lower end of each piston we drilled and tapped two $\frac{5}{8}$-in. holes and attached the lug. Then we made a special flange to fit the handle hole on the side door. The rigging, shown in Fig. 1, has an 8 to 1 ratio and in this way we get a 3-in. travel of the indicator with a 24-in. travel of the piston. This is a good rigging and can be used on a number of inclosed engines. A nice rigging that can be used on almost any engine is shown in Fig. 2. It consists of a lever *A*, a stand *B* and an eccentric *C*. The eccentric is fastened on the engine shaft *D* so that its maximum radius is in line with the connecting-rod at top center. The shaft actually should have a keyway to hold the eccentric."

Organization Chart, Union Gas and Electric Co.

Below is shown the power-house organization chart as it applies to the stations of the Union Gas and Electric Co., Cincinnati, Ohio.

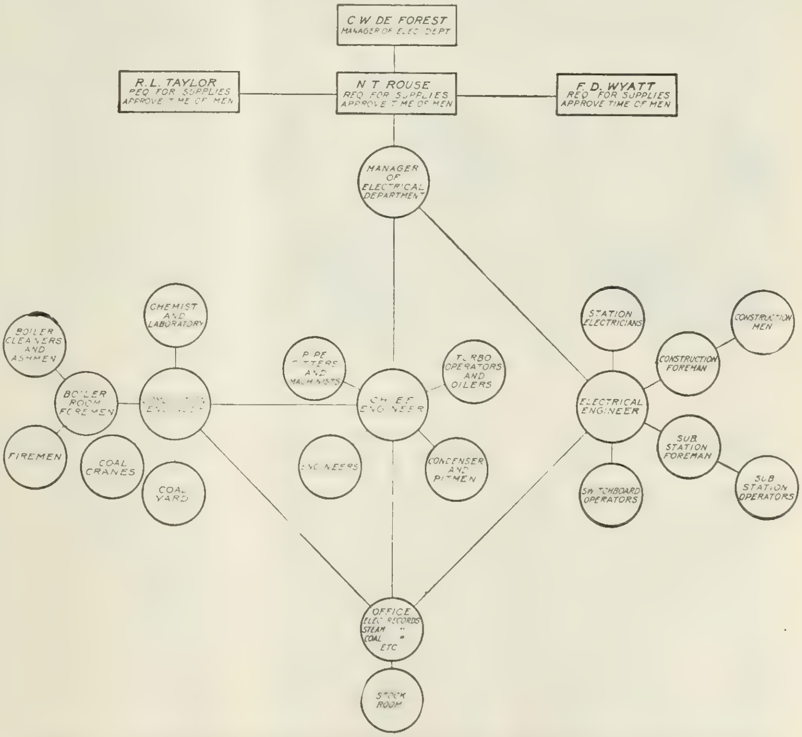


FIG. 1. POWER-PLANT ORGANIZATION CHART, UNION GAS & ELECTRIC CO.

The Electrical Study Course—Apparatus Required for Brake Tests on Motors

Describes various types of pulleys that may be used in connection with brake tests and the methods of keeping them cool. Also gives the construction of several different brakes that can be applied to the pulleys.

IT WAS shown in the previous lesson that it is necessary to provide means for limiting the temperature of a pulley that is used on a motor that is to be subjected to a brake test. The most usual method of accomplishing this is to introduce water into the interior of the pulley. To prevent the water from being thrown from the pulley it is constructed somewhat as shown in Fig. 1. The back is solid and the front is provided with a flange *b*. After the machine has been started, the water is poured into the pulley through the outside end. As soon as it strikes the interior, it is spread in a sheet over the inner periphery of the pulley by centrifugal force, and water may be added until it occupies a depth equal to the length of the flange. When the brake is applied, and the pulley rim thereby becomes heated, the water is evaporated and will finally all disappear. It is therefore necessary to replenish it from time to time.

When dealing with large machines, in which case the evaporation is great, the water may be led to the pulley through a pipe. In such instances a waste pipe may also be provided for taking off surplus water. The arrangement in Fig. 2 shows a large pulley that revolves in the direction of the arrow *A*. Water is led into the rim through the pipe *a* and is scooped up by the pipe *b*, which has its end flattened, as shown at *c*. The flow of water is regulated, by means of the valve *d*, not to exceed the capacity of the waste *b*. This method not only dispenses with the necessity of filling the rim by hand, but has the added advantage of keeping the pulley at a comparatively low temperature due to the fact that water is constantly flowing through it. When testing large machines, we thereby overcome the objectionable feature of liberating a large volume of steam that fills the room, which is attendant upon the method that relies upon evaporation. It is, however, applicable only to large-sized motors in which the friction of the pipes with the water would be a negligible quantity as compared with the other losses involved. It will be noticed that the construction differs somewhat from that shown in Fig. 1, in that an ordinary spoked wheel is used and that both rims are provided with flanges.

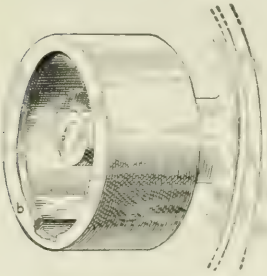


FIG. 1. SMALL WATER-COOLED BRAKE PULLEY

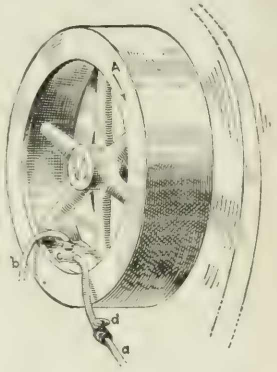


FIG. 2. LARGE WATER-COOLED BRAKE PULLEY

In addition to water-cooled types of pulleys, there are some that are air-cooled. One of these is shown in Fig. 3. It is provided with flanges *a* that radiate the heat generated. Holes *b* are drilled through the rim of the pulley between the flanges. As the pulley revolves, air is forced through these holes at a considerable velocity, thus creating a rush of air past the flanges *a*, and thereby preventing the temperature from attaining a dangerous value. The brake is placed upon the portion *c* of the pulley.

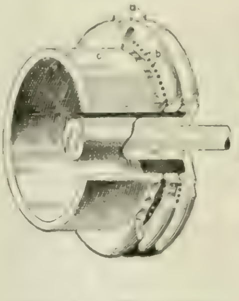


FIG. 3. AIR-COOLED BRAKE PULLEY

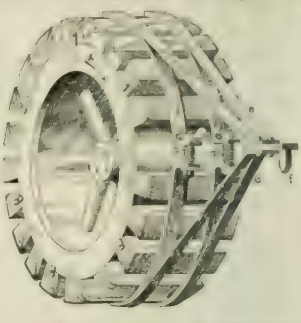


FIG. 4. PRONY BRAKE FOR LARGE MACHINE

The brakes that are used in connection with brake tests are of many different forms, but the object of all of them is to provide means for applying a friction load to the pulley of the motor and means for measuring the force exerted by the pulley in trying to drag the brake around with it. In Fig. 4 is shown a type, known as a prony brake, that is applicable to a large number of conditions. It consists of steel bands *a* to which are attached wooden blocks *b* and an arm *ee*. By tightening or loosening the nuts *d* the friction between the brake and the pulley can be adjusted. The springs *g* serve to separate the bands when the nuts *d* are loosened. The force acting to drag the brake around can be determined by placing a platform scale under the knife-edge *f* of the arm *e* and observing the pressure indicated upon it. It is understood that the pulley is revolving in the direction of the arrow *A*.

The foregoing is rather an expensive construction and many modifications of it are employed, particularly for smaller machines. One such modification is shown in Fig. 5. It consisted of a block of wood *a* that fits the pulley snugly and a piece of strong canvas belting *b* that is attached to the hangers *cc*. By means of the nut *d* the friction between the belt and the pulley can be regulated.

Another form of brake uses a canvas strap similar to the one just described, but dispenses with the block *a* and the arm *e* by using a construction such as that indicated in Fig. 6, in which *a* is a cross-bar supported from the floor by the uprights *bb*, *c* is a spring balance and *d* a beam scale. As before, the tension of the strap is adjusted by means of the nut *e*, the dragging force being determined from the readings of the two scales, as is to be explained in a future lesson. The direction of rotation would be that indicated by the arrow *A*.

Frequently, the pulleys used for brake tests are provided with flanges as shown at *a* in Fig. 7, to prevent the brake from slipping off the pulley. Side strips may be attached to the brake, as at *a* in Fig. 8, to accomplish the same purpose.

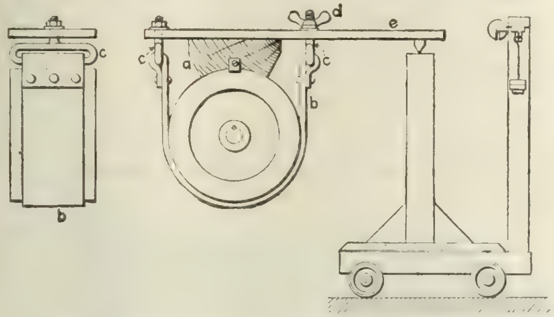


FIG. 5. PRONY BRAKE FOR SMALL MACHINES

In the following lessons the theory applying to brake tests will be developed and the manner in which the various types of brakes are employed to secure the data required will be explained.

In the problem of the preceding lesson it was required to find the size of motor that it would be necessary to install to drive the pulley of Fig. 9 at 30 r.p.m., if its diameter is 18 in., and if the weights of W_1 and W_2 are 300 and 1500 lb. respectively. The problem is one that requires us to determine the number of feet a given number of pounds must be raised per minute; that is, the number of foot-pounds per minute that the motor is required to develop. Since one horsepower represents 33,000 ft.-lb. per min., we divide the total number of foot-pounds per minute by 33,000 to find the horsepower the motor is called upon to furnish. Thus, if *P* be used to represent the power in foot-pounds per minute, we have, hp. $= \frac{P}{33{,}000}$. The number of foot-pounds per minute of the motor will be equal to the weight of W_2 minus that of W_1 multiplied by the number of feet through which W_2 is raised in one minute. That is, $P = (W_2 - W_1) \times L$, where *L* is the distance, in feet, through which W_2 is raised in one minute. The distance through which the weights are moved in one minute depends upon the speed of the pulley. In one revolution the cable supporting the weights would be moved a distance equal to the circumference of the pulley, provided there is no slip between the cable and the pulley. Thus, if *l* represent the distance moved through in one revolution, and *D* be the diameter of the pulley, we have $l = \pi D$. Substituting for *D* its value as given, namely 18 in., and for π its value (3.1416) gives, $l = 3.1416 \times 18 = 56.55$ in. Since the pulley makes 30 revolutions in one minute, the distance through which the weights are moved in one minute will be 30 times the distance they are moved through in one revolution, or $L = 30 \times l = 30 \times 56.55 = 1696.5$ in. To convert inches into feet we divide by 12, giving $L = \frac{1696.5}{12} = 141.4$ ft. Substituting in the expression for *P*, we have, $P = (W_2 - W_1) \times L = (1500 - 300) \times 141.4 = 169{,}700$ ft.-lb. per min., from which we get, hp. $= \frac{P}{33{,}000} = \frac{169{,}700}{33{,}000} = 5.14$. It would therefore require a 5-hp. motor to meet the conditions.

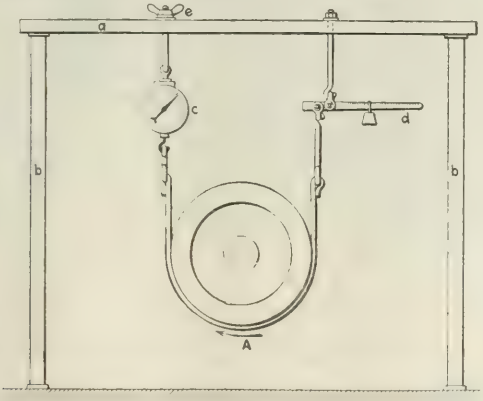


FIG. 6. BRAKE ON WHICH TWO SCALES ARE USED

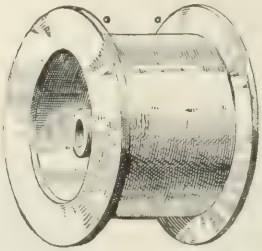


FIG. 7. FLANGED-TYPE BRAKE PULLEY

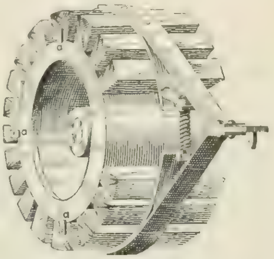


FIG. 8. PRONY BRAKE FOR MEDIUM-SIZED MACHINE

Fig. 10 represents an arm *a* keyed to a shaft *b* to which is also attached a pulley *c*. A strap *d* passes around the pulley and is fastened to it as indicated at *e*, and from it is suspended a weight *W*. Owing to the pull of the arm at *f*, the scale *g* indicated a weight of 10 lb. What must be the weight of *W* to produce this pull if the diameter of the pulley is 8 in. and the distance *l* is 2 ft.?

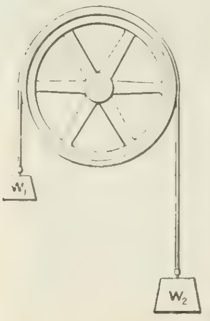


FIG. 9. TWO WEIGHTS SUPPORTED OVER A PULLEY

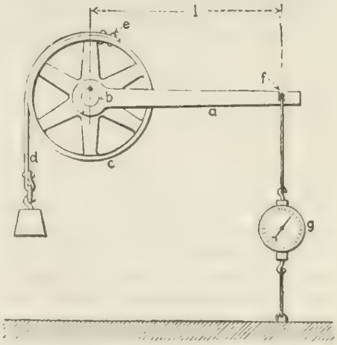
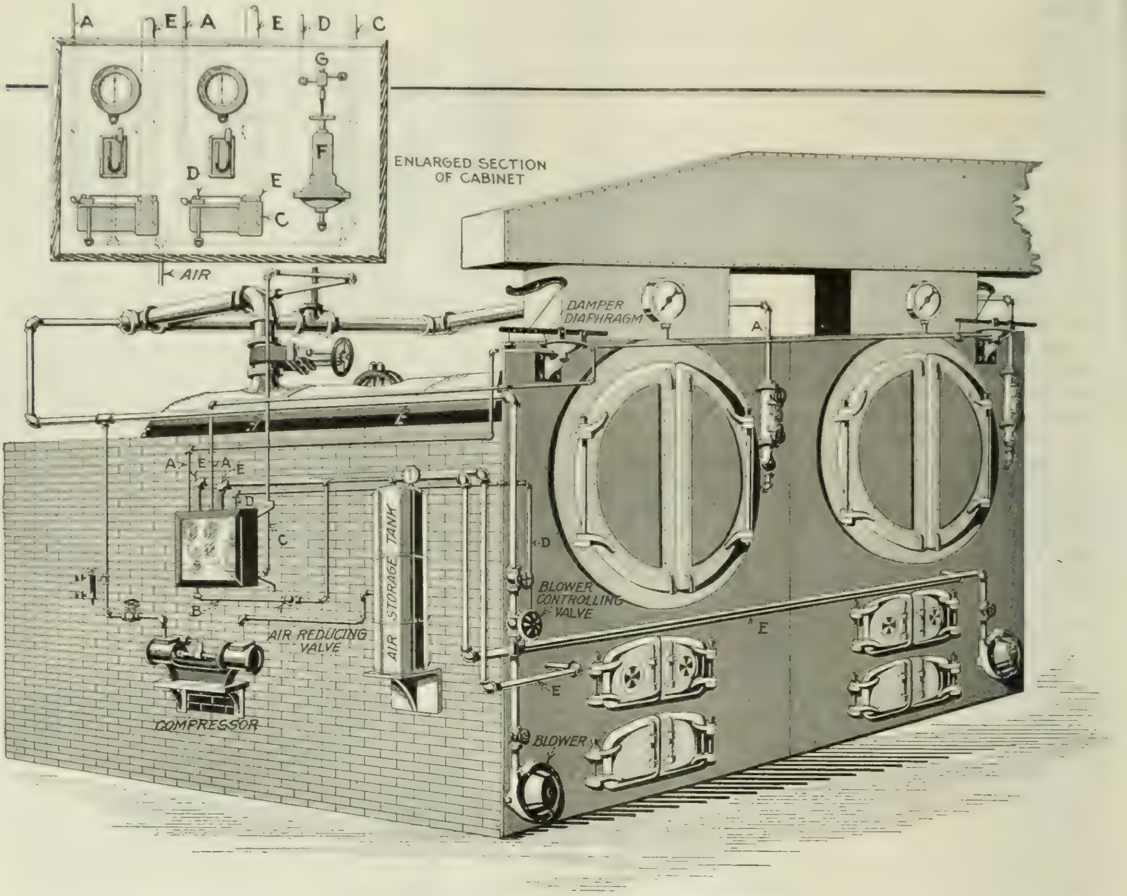


FIG. 10. BRAKE PROBLEM FOR FOLLOWING LESSON

Oil-Seal Combustion Control

In stoker-fired boiler furnaces it is the practice to regulate the feed of the stoker and the speed of the forced-draft fan by means of the steam pressure. Thus, when the steam pressure increases the stoker and the fan speed is decreased, and as the steam pressure decreases the speed of the fan and stoker is increased. Another method has been adopted by the Vapor Vacuum Heating Co., Otis Building, Philadelphia, Penn., which operates on the principle that the gas pressure in the furnace of a boiler is the logical agent for determining the amount of draft to the chimney and the quantity of air to be passed through the fuel bed to support combustion. When the steam gage shows a drop in pressure, the supply of air passing through the fuel bed is increased, and this results in a higher rate of combustion until the steam pressure returns to normal. Referring to the illustration, the pipes *E* leading from the furnace to the oil seal *C* in the cabinet convey the gas pressure to the surface of oil contained in the seal, and as the gas pressure rises or falls, the level of the oil changes, thus moving the small float *E* up or down. This float in turn opens or closes the valve *D* by means of a lever which responds to the movements of the float, thus allowing compressed air to pass through the valve *D* to the diaphragm operating the boiler damper, connection being made by means of the pipes *A*. The position of the dampers is changed in proportion to the quantity and pressure of gases generated in the furnace on account of the increase or decrease in the rate of combustion.



PIPING OF THE OIL-SEAL COMBUSTION CONTROL

Live steam from the main steam line operates the diaphragm *F*, and as the steam pressure changes, the diaphragm responds and opens or closes the valve *D*, through which compressed air from the air-storage tank passes to the diaphragm on the steam valve, which in turn controls the quantity of air supplied to the bed of fuel by whatever method is used for this particular purpose.

From the foregoing it will be seen that the movement of the waste gases to the chimney and the quantity of air supplied for combustion are taken care of individually; that is, the air for combustion is controlled by the steam pressure, and the position of the damper to the chimney by the pressure of the gases over the fire or in the combustion chamber. At the left of the illustration is shown an enlarged view of the cabinet, which contains, besides the apparatus already mentioned, a draft gage showing the pressure in the furnace and combustion chamber, a compressed-air gage, and a boiler-pressure gage. The piping and general arrangement of the system are shown in the large illustration.

EDITORIALS

What Is the Most Satisfactory Hydrostatic Test Pressure for Boilers?

IN REPORTING to the Institute of Naval Architects on the work of the British Marine Engineering Design and Construction Committee, A. E. Seaton said: "It is concluded to be quite unnecessary now to test boilers by water to double the working pressure; in fact, there is the possibility that instead of such a proceeding being a source of safety, it will become a cause of damage to the structure, especially to the staunchness or tightness of the joints. The opinion has been expressed and strongly supported that the test pressure should no longer be any multiple of the working pressure, but rather it should be an added excess such as is provided in the rules of the British Admiralty and many foreign authorities. The committee would have been content with one hundred pounds margin over the working pressure as being sufficient for every purpose for which such a test is designed."

Notice he says, "would have been content." In deference to the views of the Board of Trade, the committee adopted the following rule:

> Hydraulic test pressure is to be fifty pounds in excess of one and one-half times the working pressure for all new boilers, but is not to exceed one and one-half times the working pressure for boilers which have been in use.

Does the committee express the opinion of many when it says a margin of one hundred pounds over the working pressure is sufficient? Whether or not one agrees with the committee, one must ask if a boiler should be a hundred pounds stronger than its working pressure or within this amount, or whether it should stand without revealing weakness a stress one and a half times as great as its working pressure whatever that pressure may be. There is a great difference. By using a multiple of the working pressure, the strain is proportional for all working pressures and all boilers, presuming the latter to have been built with the same factor of safety. This cannot be so if an excess of a specific amount is applied to all boilers.

According to the high-pressure boiler rulings of authorities in North America, which call for a hydrostatic test pressure of one and one-half times the working pressure (Massachusetts requires one and one-quarter times) this margin is overstepped when two hundred pounds is exceeded. For one hundred and fifty pounds the excess pressure called for is seventy-five pounds above the working pressure, or twenty-five pounds less than the one hundred pounds of Mr. Seaton's committee. For a working pressure of three hundred and fifty pounds the excess is one hundred and seventy-five pounds. But as the boilers are designed for the same factor of safety, the stress will bear the same relation to the elastic limit in both cases.

Mr. Seaton's assertion and the evident practice of the British Admiralty will surprise many in America. Likely it would be difficult to convince engineers on this side of the Atlantic that any hydrostatic-test pressure not causing a stress in proportion to the elastic limit would be acceptable. Nevertheless Mr. Seaton's qualifications and the traditions of the British Admiralty command consideration.

Is there a good reason to reduce the hydrostatic-test pressure on boilers which carry, say from two hundred pounds pressure up?

Carbon and Commutator Wear

ALTHOUGH a great deal of study has been given to the characteristics of carbon brushes, both by brush and by electric-machinery manufacturers, there is nevertheless a fruitful field for further investigation. The effects of such characteristics as contact drop under commutating conditions, sparking voltage, thermal conductivity and also refractory properties under various conditions are all open questions. This is quite evident from the letter, "Carbon and Commutator Wear," by R. E. Hellmund, on page 868 of this issue, referring to the influence of temperature on the carrying capacity of brushes, and taking issue with a communication by Warren C. Kalb, appearing in *Power* of March eighteenth, in which the statement is made that brush wear is influenced largely by the temperature at the contact face. It would seem that the difference in opinion here noted results from a consideration of temperature variation over ranges that are widely separated. It is undoubtedly true that within limits increased temperature has very little influence on brush wear. However, it is understood that the temperatures referred to by Mr. Kalb as causing appreciable brush wear were high enough to induce glowing at the brush face or at least to create momentary incandescence at certain points on the brush contact. Until such temperatures as this are reached, it is probable that variations in temperature influence brush wear to a negligible extent. For this reason variations in temperature produced by external means would have little effect unless they were carried high enough to cause glowing of the carbon.

It is quite possible that arcing due to either mechanical vibration or high sparking voltages may exist without serious wear provided the interval during which this arcing exists at a given spot is very brief. In such case the temperature of the surrounding carbon would not be brought up to a point at which any pronounced disintegration would take place. Passing a high current density through the brush while this condition exists, might bring up the temperature over the entire contact face near enough to the destructive point so that the added effect of the arcing, even for a very brief period, would result in disintegration.

Mr. Hellmund brings out another factor which undoubtedly has a pronounced influence on brush and commutator wear. This is the ionization of the carbon as well as the copper particles at the contact of the brush on the commutator. This phenomenon has sometimes been spoken of as an electrolytic action. That such a condition exists is evident from the fact that a positive brush will in nearly all cases have a different contact drop from the negative brush of the same material on the same commutator. The effect of the brush polarity on the commutator surface is also different, as can be seen where positive and negative brushes bear on different paths on the commutator.

The instance cited in which fifteen to twenty volts sparking voltage was impressed across a brush contact without injury in the absence of load current might be explained by two conditions. Either a very brief commutation interval, allowing insufficient time for appreciable temperature rise at any given spot on the brush face, or the absence of ionization due to there being no load current through the contact.

Mr. Hellmund has raised a point of vital interest to brush manufacturers as well as to manufacturers of dynamo-electric machinery. It would be interesting to learn the full details of his experiments and of any other research work that has been conducted along these lines.

Prospects for a Power Survey

WITH the opening of the Sixty-sixth Congress the movement to obtain appropriations for a power survey of the United States is again under way. The estimates of appropriation presented by Secretary Lane to the last Congress have been renewed and are now before the Appropriations Committee of the House. These appropriations, which, owing to the filibuster at the close of the last session, failed of passage, will, if made, permit the Geological Survey to expend two hundred and fifty thousand dollars in studies of power supply during the coming fiscal year.

Of this amount fifty thousand dollars is to be used in a general engineering and statistical survey of the power resources of the United States. Present and possible sources of power will be surveyed and detailed maps prepared showing the location of existing power plants and transmission systems. Undeveloped water powers will be more critically studied and estimates of this resource will be revised. A new service is planned with a view of bringing together manufacturers desiring to establish new plants and concerns having surplus power available for use. Monthly and annual reports of the progress of power production are also contemplated as a barometer of electrical development

The balance of the appropriation will be used for an intensive survey of power conditions along the North Atlantic Seaboard. It is upon this item that Secretary Lane is dependent for means to investigate the possibility and usefulness of his super-power plan for the interconnection of the power centers of the Atlantic Coast, thus making possible more complete utilization of water power and the electrification of trunk-line railroads. If this appropriation is authorized, the Secretary proposes to enlist the coöperation of the electrical industry in a careful economic and engineering investigation of the future power requirements of this region and of the best means of supplying its needs, taking into consideration the most efficient possible use of natural resources.

The Secretary believes, that the solution of the problem of power supply is just as vital to the future welfare of the nation as are the problems of transportation or crop production, for the investigation of which millions are expended annually. Indeed this belief was substantiated by many events of the past two years. At the present time Congress makes no appropriations whatever for the study of power resources, and it is the opinion of many operators that the industry has not heretofore received the public support that its national importance justifies. If the appropriations requested by Secretary Lane are granted by Congress, they will form the basis for work that not only will be of great assistance to the public, but will bring about a realization of the key position of the power business in relation to other industries.

Handling Ice at Holtwood Hydro-Electric Station

OUR many readers in hydro-electric plants will find much to interest them in the article on handling ice situations at Holtwood, printed elsewhere in this issue. Fortunate are the crews of stations where there are no ice troubles, but particularly fortunate are those in stations where there is no ice to give trouble. In the history of Holtwood, which is on the Susquehanna River a short distance up stream from Perryville, Md., there has been but one total interruption because of ice, and this happened, as shown by the ice-trouble record in the article, in 1912, when the station was new and in the first winter of its operation.

But to achieve the splendid record of freedom from ice troubles the engineers at Holtwood have been busy; it has required considerable study, preparation and organization. What is done and how is told in the article.

Of course it is frazil ice that gives the most trouble at Holtwood, as it does elsewhere. This is a very trying trouble-maker. It is Old Dame Nature herself who forms it, and man might as well attempt defiance of gravitation's laws as to try to prevent her filling a body of water with these fine crystals. And once formed, once into the screenhouse and into the turbines without preparations for its visit, the generators cease to function, particularly if the greater part of the turbine is submerged, as nearly all are at Holtwood.

But the crew there is extraordinarily vigilant. As frazil ice forms with astounding suddenness, with a comparatively minute drop in temperature, and on a rising peak load at Holtwood, the river temperature is closely watched, recorded and reported to the operator. Steam or electricity is not used to heat the water that fraction of a degree needed to avoid or dissolve frazil ice. The screens and gates are opened to let the crystal-impregnated water rush through into the tailrace. Steam is used to thaw away the ice should a machine become blocked with it. How Holtwood handles its ice is a valuable contribution to the literature on the subject.

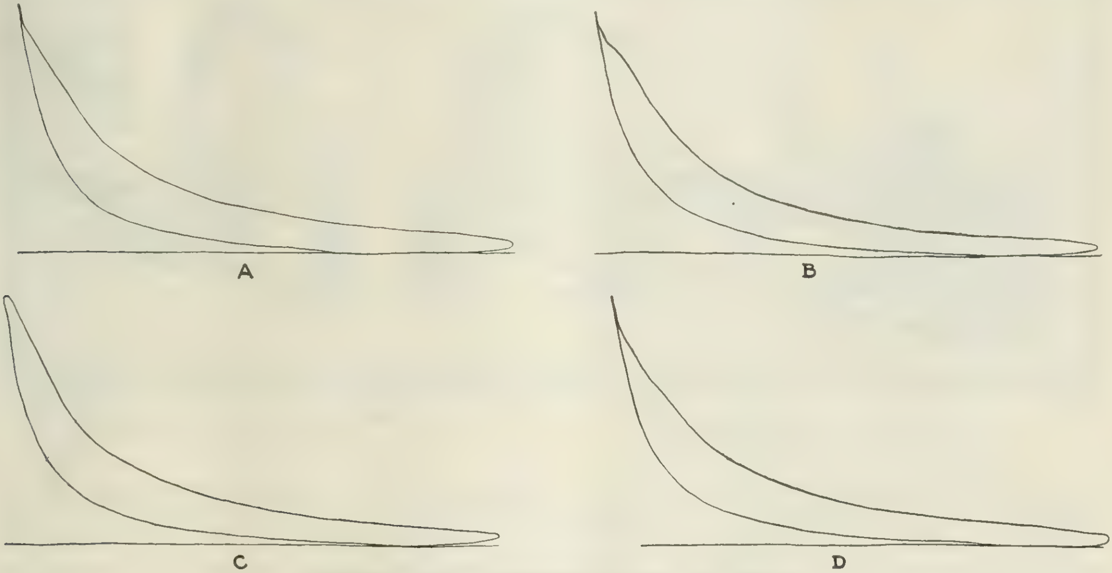
Chief engineers of the textile mills at New Bedford, Massachusetts, struck on May nineteenth for a wage increase and caused a complete shutdown of plants employing thirty thousand operatives. The mill firemen are supporting the engineers in their demand for forty-two dollars weekly for engineers in charge and thirty-seven dollars weekly for operating engineers with time and one-half for work in excess of forty-eight hours weekly. Well, it costs as much in proportion for an engineer to live as it does for the man getting a fat salary.

The duty of every chief engineer is to devote attention to educating the personnel of the plant to the proper and most advantageous use of the equipment to obtain the best results from its use.

· Correspondence ·

Curious Explosions in a 750-Horsepower Diesel Engine

Diesel engines are not supposed to be preigniting, but we had one instance where this was the case. Upon starting up a new 750-hp. unit, curious noises accompanied its operation and trouble was experienced due to faulty valve-setting and leaky valves. The noises were eliminated with the exception of one peculiar cracking sound that occurred at times during the noon shutdown period or after stopping the engine at night. This trouble was brought to the attention of the makers, but nothing was found mechanically wrong, and by some it was thought that the noise was caused by the contraction and expansion of the metal. It was also observed once shortly before starting time, and it was puzzling, to say the least.



DIAGRAMS WITH DIFFERENT POINTS OF IGNITION

One noon, about two minutes after stopping the engine, a bang occurred. We were certain that the fuel valves and the other valves were in good working order, the engine having been working smoothly and with a clear and colorless exhaust. The circulating water was not cut off, as it was our custom to allow it to circulate during the shutdown period. We went up on the operating platform and found a little smoke issuing from the air-valve pipe of the fourth cylinder from the flywheel side of the engine. This showed that oil gas was forming and that explosions in a mild form were occurring during the shutdown period.

Then we began to investigate as to why gas should explode when the compression-breaking lever had been raised, and also to ascertain if the lever was in working order. The exhaust valve was closed, and in about two minutes after the first explosion another followed, flames issued from the air-valve pipe, and the engine was turned over backward one revolution. Although the second explosion was a heavy one, the engine was not damaged.

We finally came to the conclusion that the explosions were due to the ignition of gas from oil, and we were puzzled as to where the oil was coming from, as the fuel and pump valves were in the best of condition. Then it was recalled that the manufacturers had supplied a glass drip cup on the exhaust- and air-valve cages and had advised us to lubricate the exhaust-valve spindles with kerosene oil. I am of the opinion that this oil collected in the poppet-valve cages and did not pass the valve when the engine was running; but when the engine was slowly coming to rest and the exhaust-valve lever was held up for breaking the compression to avoid turning the engine backward, the collected oil passed the exhaust-valve opening into the cylinder, and then the exhaust-valve closing, the gas from the kerosene exploded due either to carbon deposits or to a hot piston.

The accompanying indicator diagrams were taken from this same engine, and I would like to know why the diagrams *A*, *B* and *D* show different points of ignition from diagram *C*, when the fuel-valve gages of all cylinders were made equal in stopping time. It has been observed that, when running, the gages on the valves did not remain the same—that is, reading from twelve to fifteen thousandths more—and also that all did not increase in the same proportion. These diagrams were all taken from the same cylinder without making any alterations. Who can give an explanation as to the difference in the point of ignition? P. P. TALATY.

Ahmedabad, British India.

An Emergency Engine Repair

The engineer of a certain factory was such a thoroughly competent man, so steady and reliable, and had been there so long that the manager had forgotten that anything could go wrong with a steam-power plant; and as this engineer never seemed to have anything to do, he had come to be regarded somewhat as an expensive luxury.

On one occasion when it was necessary for him to be away for several days, instead of a competent man being put in his place, as the engineer recommended, the fireman was put in charge of the engine, and consequently about the middle of the afternoon of the fourth day an S. O. S. call came from this factory to the machine shop where I was employed.

On arriving at the factory I found them pouring oil on the engine's main pillow block, which was so hot that the babbitt had commenced to run. This factory was so far behind with its orders that it could not be stopped for repairs, so we loosened up the quarter brasses and turned a stream of water on the bearing, hoping to cool it down enough to enable the engine to run until the next Saturday night; but it was too far gone. I therefore decided to babbitt the bearing that night.

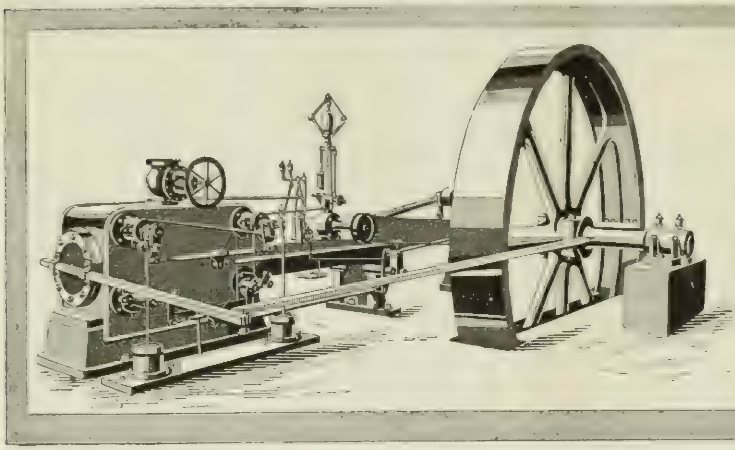


FIG. 1. HOW THE SHAFT OF THE ENGINE WAS ALIGNED

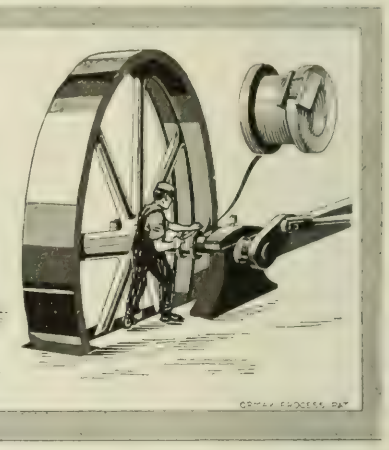


FIG. 2. SMOOTHING THE GOVERNOR BELT PULLEY

On my asking for two of the boys from the shop for helpers, the manager of the factory objected on account of the expense, saying that he would give me two of the factory laborers. I strenuously protested, as they, knowing nothing of such work, would be of little use to me. However, I had to take them.

Closing time found everything in readiness. The outboard end of the shaft could be jacked up, but conditions were such that the crank end had to be raised with a 3-ton tackle. I chipped the babbitt out in a hurry and, allowing the shaft to rest in the outboard bearing, set the crank end a little high above the center (about $\frac{1}{16}$ in.), so that after some months of wear it would be worn down to the center.

Having the shaft set for height, and not having time to take out the piston and crosshead to put a line through in the usual way, I took off the head-end cylinder head and with a long straight-edge lightly clamped against the back end of the cylinder, and about central as to height and level, the shaft was set square by tramming from the straight-edge to the crankshaft, improvising an excellent tram by driving a round-headed nail in each end of a stick of the right length and about one inch square, first calipering the shaft to make sure that it was parallel (See Fig. 1). The bottom of the box was then poured, the shaft lifted out and the surplus babbitt chipped off. Then the shaft was replaced and tested for alignment. The quarter brasses were poured and fitted, the cap being poured last.

While I was replacing the back cylinder-head and connecting-rod, I had the helpers take down the tackle used in lifting the shaft, but being sleepy and not used to such work, they let the tackle fall, and it struck the governor belt pulley and broke a big piece out of it. It was pure luck that it did not hit the eccentric.

The factory must start at 7 o'clock and it was then about 5:30. Some pieces of tin were fitted to the pulley and babbitt was poured to fill the vacancy where the piece was broken out, Fig. 2. I then built up a wooden frame to serve as a tool rest and, using a carpenter's chisel as a hand tool, the engine was run on the throttle while I turned the babbitt down and smoothed it up true. The engine was stopped, the governor belt was put on and we started up again at just five minutes before seven. M. L. Lowrey.

Livermore, Calif.

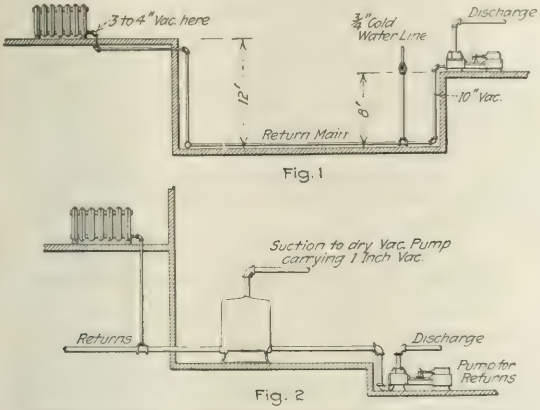
What Makes the Exciter's Voltage Slow to Build Up?

Referring to C. S. Harrison's letter, "What Makes the Exciter's Voltage Slow to Build Up?" in *Power* of Apr. 1, it may be that the series- and shunt-field windings are connected in opposition. This would make the exciter sluggish in its response to variations in the load. It is possible that the field excitation of the exciter may be weak due to a poor connection somewhere in the field circuit. I would advise testing the voltage drop across each field coil. Poor brush contact would cause the machine to be slow to build up, as would also brushes of too high a resistance. However, brush trouble generally manifests itself by considerable sparking at the commutator. L. A. Cole.

Columbus, Ohio.

Difference in Heating Systems

In the illustration Fig. 1 shows the return piping of the heating system in one plant. This system was supplied with exhaust steam supplemented by live steam brought to atmospheric pressure through a reducing valve. The radiator valves were thermostatically controlled. A gage at the radiators showed about 4 in. vacuum, while the pump gage showed 10 in., probably on account of having to lift the returns from the main, which was 8 ft. below the pump. A ¾-in. pipe connection for cold water had to be kept wide open, for when no cold water was used the pump would become steambound and could not lift the water from the return main. This is the only system I ever saw arranged in this way, and it looks to me like a poor job.



FIGS. 1 AND 2. PIPING OF TWO HEATING SYSTEMS

Another heating system that I had charge of was arranged as shown in Fig. 2. This one took much less steam, using steam at atmospheric pressure, and a vacuum of one inch was carried on the returns.

I would be pleased to have this subject discussed and learn the opinion of other readers.

Chicago, Ill. L. B. Shields.

Graphite for Reducing Slag Formation on Exterior of Boiler Tubes

A statement appearing on page 340, of the Mar. 4 issue of *Power*, in an article reporting the meeting of Illinois Chief Engineers, deserves having attention focused upon it. This statement reads: "Formation of slag on the lower tubes of a water-tube boiler has been prevented by the application of graphite and the use of a hand lance in addition to the mechanical blower."

This is interesting, because it is the first pass of a boiler that does the most work, hence interference with heat transfer here interferes most with boiler efficiency. It is the formation of slag on the first few rows of boiler tubes that has so far caused one of the most difficult problems with which the manufacturer of mechanical soot blowers has had to deal, and it is not yet solved. If the use of graphite is a solution or even a partial solution, it is to be highly advocated, especially in installations using mechanical draft, operating with settings insufficiently high, and at high ratings; because it is especially in such cases that flue-gas dust and slag are most likely to cause trouble. The use of low-grade fuels with high ash content, necessitating high draft intensities to maintain capacities, has tended to make the slag trouble the more serious.

Graphite is a combustible. It oxidizes in an oxidizing atmosphere. Furnace gases are oxidizing. With a temperature of 2400 deg. F. and higher over the fuel bed, with a temperature of 1700 deg. F. and thereabouts around the first row of tubes, the questions are: Will graphite stand up for any length of time? In applying graphite what vehicle is employed to withstand these high temperatures? How long does a coating of graphite last under these circumstances? Is the application practical so far as the heat resistivity of graphite and its vehicle is concerned?

And another pertinent question would be: Even if graphite and the vehicle making it into a paint have the requisite heat resistivity, which means a certain life under actual operating conditions, how is this graphite paint to be applied? The first few rows of boiler tubes are not accessible when once installed, and difficulty of applying the graphite would be a serious detriment to its use.

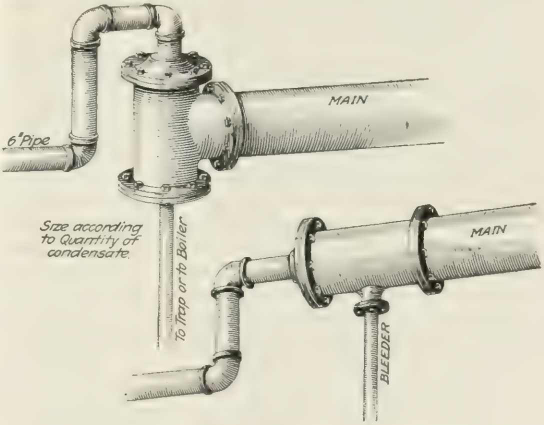
If the use of graphite for preventing furnace slag from forming across the outside of the first few rows of tubes, obstructing draft, interfering with boiler efficiency and introducing the possibility of tube troubles, is as effective as it is for preventing the adherence of scale to the inside of the tubes, its application is certainly worth advertising and encouraging. What is the experience of operating engineers? What are the criticisms of the foregoing reasoning? The writer hopes he is wrong. S. B. Wilkinson.

Chicago, Ill.

Changes in Header Piping

If I had my way, I would never drain a main as shown by Mr. Wakeman, on page 327 of the Mar. 4 issue. I would deem such connection insecure under any pressure. It would be better to put in a flanged tee with the run vertical or horizontal according to the available space, as shown by accompanying illustrations. This would admit of making a proper connection of the bleeder pipe to the tee instead of screwing it into a threaded hole in the pipe. A. Dolphin.

Jamaica, L. I.



TWO METHODS OF PIPING BLEEDER PIPE

Easily Made Ferrules

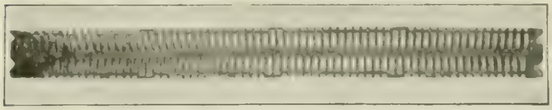
The thimble ferrule described by William H Watson on page 741 of the Apr 13 issue of *Power*, will answer the purpose on a handle for a small tool, but old thimbles are a rather scarce article around a power plant.

For years engineers have been in the habit of using the end caps from burned-out inclosed fuses for ferrules. Usually, there are different-sized fuses in plants, the caps on the 15-ampere 250-volt ones being ½ in. in diameter, gradually increasing in diameter as the amperage increases. The 200-ampere 250-volt fuses have caps 1½ in. in diameter, and the weights of the caps are just about right for the different-sized ferrules.

Portsmouth Ont., Canada. **James E. Noble.**

Grate Bar Used Nineteen Years

The illustration shows a grate bar that I have used for nineteen years. It may be an easy matter to find bars that have been in use longer, but not of this type, and they may not be so well preserved.



GRATE-BAR AFTER 19 YEARS OF SERVICE

New Haven, Conn. **W. H. Wakeman.**

Carbon and Commutator Wear

Referring to the discussion by Warren C. Kalb on "Carbon and Commutator Wear" in the Mar. 18 issue of *Power* and my previous letter in the Feb. 4 issue, I would like to make a few additional remarks. It is to be expected that, as mentioned by Mr. Kalb, brush wear is affected by a number of factors outside of current density, sparking voltage and peripheral speed. It is, of course, desirable that whatever such factors may be, their influence should be studied.

One of the factors mentioned by Mr. Kalb is temperature. While no doubt temperature has some influence, I am inclined to think that Mr. Kalb attributes too much importance to this point. Tests made on certain carbons indicate that within limits increased temperature had very little influence on the wear. The temperature was varied in this case by external means independent of current density, sparking voltages, etc. Again, other tests indicated that even if the temperatures were carried rather high by means of high current densities, the wear was influenced but slightly as long as there was no arcing. Further, it was found that quite appreciable arcing caused either by mechanical vibration or by high sparking voltages resulted in very little wear as long as the current densities were low. Considerable wear was obtained only with a combination of appreciable arcing and appreciable current densities, although the temperatures were lower than in some of the other tests giving small wear. It seems, therefore, that the wear is not simply a question of temperature, but more due to the arcing and the amount of ionization at the brush which, in turn, is, of course, influenced by local temperatures, current densities, etc., to a certain extent.

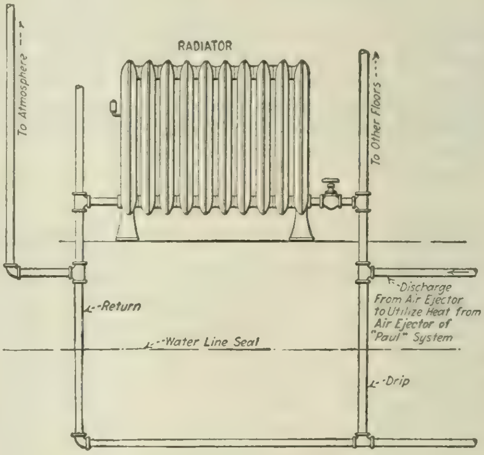
Since Mr. Kalb questions my statement regarding permissible sparking voltages of 15 to 20 volts across the brush, I wish to say that extended tests with such voltages and without load currents showed carbon wear amounting to only a small percentage of the wear obtained with the same carbons in actual service; that is with smaller sparking voltages and rather high current densities. The arcing voltage in the tests was not neutralized, but actually existed under the brush. The results were as surprising to me as they probably were to Mr. Kalb and convinced me more than ever that a lot of research work is needed along this line. Whatever carbons stand the highest current densities together with the greatest amount of sparking should certainly find a wide field of application. While commutating poles have eliminated sparking to a large extent, there are, in actual practice, still a lot of almost unavoidable causes for sparking. It is therefore best to realize this and develop carbons that stand up fairly well under these conditions. **R. E. Hellmund.**

East Pittsburgh, Penn.

Utilizing Heat from Ejector Exhaust

In buildings equipped with the "Paul" system in which a vacuum is carried on the air line from the radiators, the vacuum is usually produced by means of a small steam ejector. Considerable heat is carried off by this ejector as an inspection of the exhaust pipe from it will show.

To utilize this waste heat a connection can be made to radiators supplying heat to a hall or stairway with the piping so arranged that these radiators cannot be shut off. Provision must also be made for separating the air from the water in the return piping. These radiators must be two-pipe, equipped with inlet and outlet piping so that the mixed steam and air can sweep through them. The illustration is intended to show the application of this method to a two-pipe system with a wet return.


To Atmosphere
RADIATOR
To Other Floors
Return
Water Line Seal
Discharge From Air Ejector to Utilize Heat from Air Ejector of "Paul" System
Drip

PIPING OF RADIATOR

Another way to utilize the heat from the ejector is to discharge the exhaust into a return tank several inches below the water line, thus imparting the heat to the water in the tank, the air escaping at the open vent. The return tank in one case is an open one into which the vacuum pumps discharge. **W. T. Meinzer.**

Brooklyn, N. Y.

Inquiries of General Interest

Short-Stroking Pump Uses More Steam—Does a steam pump use more or less steam when it short-strokes? M. C.

When a direct steam pump short-strokes, there is less water pumped and less steam used per stroke; but more steam is used in proportion to the length of stroke and the amount of water pumped per stroke, because there is a larger proportion of clearance space and a larger waste of steam in the steam cylinder.

Precautions Against Sticking of Safety Valve—What is the best way to guard against the sticking of a safety valve? W. R.

To know that the valve parts are clear, the valve should be raised by hand at least once in a five-hour run, and the pressure in the boiler should be raised to the blowing point at least once each day to observe that the valve blows at the proper pressure.

Size of Water-Column Connections—What size of pipe should be used to connect up a water column of a horizontal return-tubular boiler? R. K.

The minimum size of pipes and connections used should be 1 in. For a power boiler the water connection to the water column should be of brass and made up with plugged cross-fittings to facilitate cleaning and be fitted with a drain cock or valve not less than ¾ in., with suitable point of discharge for blowing out the connection.

Greater Economy of Four-Valve Engines—Why are four-valve engines more economical than single-valve engines? W. N. C.

Single valves are more likely to be wasteful from leakage of live steam direct to the exhaust and are provided with longer steam passages with more waste cylinder spaces than necessary for four-valve engines. In addition four-valve engines are capable of such design of valve gear as to obtain independent adjustment and operation of admission and exhaust for each end of the cylinder with the most desirable distribution of steam.

Equalizing the Load on Direct-Current Generators—We have two motor-generator sets, each consisting of a 2200-volt synchronous motor driving a 275-volt direct-current compound-wound interpole generator. One of the sets is 150-kw. capacity and the other 200-kw. capacity. The machines operate in parallel and are connected to the switchboard with the same size cables. The conductors connecting the 200-kw. machine to the busbars are about twice as long as those on the 150-kw. unit. Why does the 150-kw. unit take more than its share of the load when the machines are connected in parallel? Is it on account of the shorter connection between the generator and the switchboard on the 150-kw. unit? C. A. M.

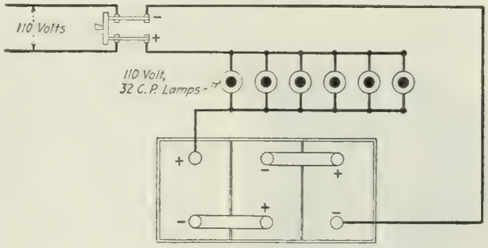
There are a number of causes that would make the 150-kw. machine take more than its share of the load, one of them being the difference in the length of conductors connecting the machines to the switchboard. If the machines had been located so the longest connections would have come on the smaller machine, no doubt it would have improved conditions. If the characteristics of the two machines are identical, then the cross-section of the conductors running from the large machine to the switchboard should be more than 100 per cent. greater than those on the small machine. It may be possible to improve conditions by placing a thin german-silver or iron washer under the equalizer lugs of the small machine, so as to increase the resistance of the equalizer connection.

Increasing the resistance of the compounding shunt on the large machine by reducing its cross-section, or decreasing the resistance of the shunt on the small machine by increasing its cross-section, should improve conditions. Probably the compounding shunt on the 200-kw. machine is of a lower resistance than that on the 150-kw. unit, and by interchanging the shunt it may be possible to accomplish the desired results. Shifting the brushes on the two machines may be tried. Moving them backward on the large machine will tend to give this machine a rising-voltage characteristic, while shifting them forward on the small machine will tend to give this machine a drooping-voltage characteristic. This will tend to make the 200-kw. unit take more of the load and the 150-kw unit take less. However, if the commutating zones are narrow on the machines, it may not be possible to shift the brushes without causing severe sparking.

Bringing the main polepiece closer to the armature on the large machine by placing iron shims on back of them may bring about an improvement. However, care must be exercised in doing this, because shims improperly placed would increase the reluctance of the magnetic path and have an effect just opposite to what was desired. It is doubtful if a satisfactory adjustment can be obtained by any one of the foregoing suggestions alone, but will have to be accomplished by a combination of them by applying the cut-and-try method.

Connections for Charging Storage Batteries—I would like to know the arrangement of 32-candlepower carbon lamps necessary to charge a three-cell automobile storage battery from a 110-volt direct-current circuit. J. H. H.

The diagram shows the connections for charging a small three-cell storage battery from a 110-volt circuit through a lamp bank. Care must be taken to get the positive terminal of the circuit connected to the positive terminal of the battery. When the connections are made properly, the lamps will be giving a lower candlepower than when connected directly across the circuit. About six 32-candlepower or twelve 16-candlepower carbon lamps are required. Of course the number of lamps will depend upon the size of the battery.



LAMPS IN SERIES WITH BATTERY

Eccentric Form of Crank—For operating a valve gear, when and why is an eccentric used in preference to a crank? W. D.

An eccentric is in fact a crankpin whose diameter is large enough to include the crank arm and crankshaft. When a reciprocating motion is to be obtained from a shaft and the crank must be placed between the ends of the shaft, the eccentric form must be used to avoid cutting the shaft to make room for the crank. An eccentric form of crank is preferable when it is desirable to obtain the smoother motion and greater strength of an enlarged crankpin and also greater compactness of design suitable for varying the angular position of the crank on the shaft.

Condensed-Clipping Index of Equipment

Clip, paste on 3 x 5-in. cards and file as desired

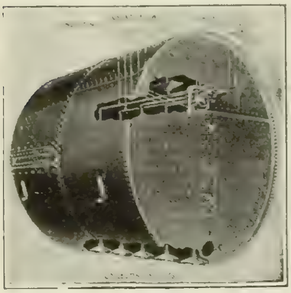
Pump, "Fulflo," Motor-Driven
Fulflo Pump Co., Blanchester, Ohio
"Power," Mar. 25, 1919

This pump is built in ½, ¾, 1 and 1¼ in. sizes arranged for either floor or wall mounting, and is equipped with ⅙, ¼, ⅓ and 1 hp. motors respectively. Capacity of machines at [illegible] r.p.m. is 21 gal per min with an 11-ft. head, 20 gal per min with a 12½ ft. head and 11 gal. per min with a 21-ft. head. Pump is of the centrifugal type, having intake and outlet located at the top. The impeller is of the semi-inclosed type and is supported by a bearing at either end of the impeller shaft.

Switch, Blackburn-Smith Inclosed
Blackburn-Smith Corporation, 105 West 40th St., New York City
"Power," Mar. 18, 1919

Switch is of the single-pole, double-brake type designed for use with tanks, to regulate water level between high and low limits. Regulation is obtained by a float operating the switch, which in turn actuates a solenoid controlling mechanical or other electrical devices.

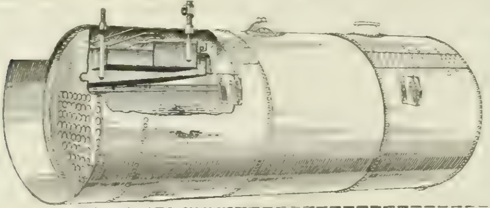
Cleaner, Geyser Boiler
Geyser Boiler Appliance Co., Detroit, Mich.
"Power," Mar. 4, 1919



This system consists of a number of connecting nozzles attached to pipes so as to distribute the nozzles along the bottom of the boiler shell of the Scotch-marine type. Nozzles are piped to a valve chamber that has three holes, one at each side and one at the top. A main blowoff valve is provided, and when turning the valve handle to, say, No. 1 on the dial plate, communication is opened between No. 1 connecting nozzle and the main blowoff pipe, thus blowing out the sediment in the vicinity of the nozzle. This operation is repeated by moving the valve until a complete revolution is made.

Boiler, Parker Double-Service
Thomas T. Parker, Brooklyn, N. Y.
"Power," Apr. 29, 1919

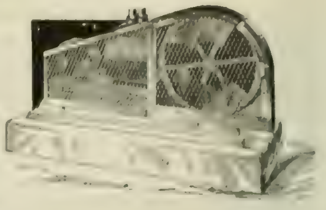
This boiler contains a device for separating scale-forming solids, mud, oil and other foreign matter. The apparatus consists of a live-steam feed-water purifier located in a horizontal fire-tube boiler and having two troughs. Feed water enters the first trough and, overflowing to the second, comes in contact with the live steam. Water flows from the second trough to the body of the purifier and, passing under a baffle plate, flows through a slotted end of the separator into the boiler.



Patented Aug. 20, 1918

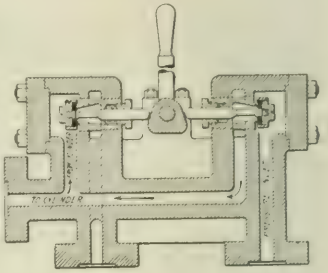
Guard, Steelcrete Machine
Expanded Metal Engineering Co., 8 West 40th St., New York City
"Power," Mar. 25, 1919

Steelcrete mesh machine guard is made of expanded metal, steel plate being cut and pulled out into a fabric of diamond-shape meshes, the diamonds being joined at their "bridges" by a short section of the unsheared plate. The sheets are attached and fitted to angle-iron frames by means of bolts, rivets or spot-welding. The mesh does not loosen up or sag, neither does it disintegrate in case one or more strands are fractured.



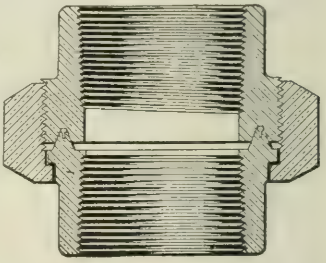
Valve, Hydraulic Operating.
Vance-Vetter Co., Pittsburgh, Penn.
"Power," Mar. 18, 1919

This hydraulic operating valve is made with flat disks that are easily renewed without disconnecting the valve or piping. The valves are operated by a cam movement, and each valve has a positive stop for open, flow and closed positions, and they cannot creep. When the handle is released to the center position, it centers and closes the valve automatically. The valve is designed for pressures up to 3000 lb. per square inch.



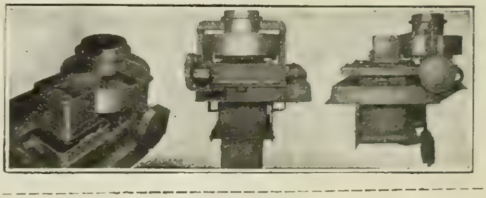
Union, Edward Gasketless Double-Tight
Edward Valve and Manufacturing Co., 72 West Adams St., Chicago, Ill.
"Power," Feb. 25, 1919

In this union the contact joint is made with a grooved V-shaped face, and the other is made with a split tongue. The faces of the tongue and groove are made with about two degrees difference of angle, and the joint is made at the narrow part of the V-groove, thus giving a somewhat flexible joint. No gasket is used. This construction gives two separate independent contacts of the split tongue in the groove.



Scale, Reliance Automatic Coal
James A. Brady Foundry Co., Chicago, Ill.
"Power," Apr. 8, 1919

The scale is designed for the continuous weighing of coal and is said to be accurate within one per cent. It is of all cast-iron construction and has a straight-sided hopper. Hardened-steel knife-edges are housed in a cast-iron box with felt washer to exclude dust. The ratio of the two arms of the balanced lever is four to one. The operating shaft is inclosed in a dust-proof case and is carried on ball bearings. If desired, flange wheels are attached to the steel frame, making it portable.



Refrigerating Engineers Approve Tentative Safety Code

HELD at Hotel Sinton, Cincinnati, May 19-21, the sixth Western meeting of the American Society of Refrigerating Engineers was a decided success. The outstanding feature of the convention was the adoption as it stood of the Tentative Code for the Regulation of Refrigeration Machines and Refrigerants, which has been in the course of preparation for the last two years by a committee of the society. The plan was to prepare a code that would be authentic and right for the guidance of municipal or state legislators and to insure uniformity in the regulations. On this account it was made as simple as possible, giving protection with a minimum amount of trouble and equipment. The code applies to every refrigerating machine employing ammonia, carbon dioxide, ethyl chloride or sulphur dioxide as a refrigerant. It is considered tentative and is open to correction or addition. The committee is now awaiting the results of the work done by the subcommittees on welding and on the specification of a standard ton of refrigeration. There will be additions to the code on these two items, and further suggestions are solicited by the committee. About twenty cities have now adopted the code as it stands. In the discussion reference was made to the preparation of a separate code for an electric-driven plant; this to avoid complication and preserve the simplicity desired. The present code will appear in full in an early issue of *Power*.

President G. E. Wells made a general address, reviewing briefly some of the recent work of the society and requesting more activity in securing new members. Owing to the many new applications of refrigeration, he said, opportunities for the refrigerating engineer are greater than ever before. More attention should be paid to the appearance of plants, particularly in the Southwest. Because of the higher cost of fuel and supplies, improved efficiency is a prime importance and labor must be given more consideration than in the past.

MR. HILLER'S PAPER

A paper by N. H. Hiller, describing a "Shop Method for Testing Refrigerating Machines" was received with interest. In the past 15 years the company with which the speaker is connected has installed four test plants at an average cost of $5000. As they required the services of five men, the cost of operation was high. Many difficulties were encountered and long delays made it difficult to interpret changes in the refrigerating apparatus. Consequently, a new method employing a high-pressure orifice was tried. The compressor discharged into a high-pressure receiver and then through a valve into a low-pressure receiver equipped with a special form of nozzle recommended by the Compressed Air Society, and a manometer. By means of the regulating valve between the receivers the pressure was kept constant in the high-pressure tank. The equipment gave excellent results with compressed air, but was rather complicated. In an effort to simplify the plant an adaptation of this nozzle method was used. The problem was to obtain constant conditions of pressure and a means of measuring the volume of the gas pumped and thereby its weight. Receivers were employed as before, temperatures measured on both sides of the nozzle, and an oil manometer was used. A sprinkling trough was provided to reduce the superheat in the high-pressure receiver to a temperature slightly above that due to the pressure, and grids and baffles were installed to break up the gas current and prevent vortex action. This apparatus gives all the conditions of a complete refrigerating plant except that of a saturated gas suction, and to meet this a small double-pipe condenser and a calibrated receiver with gage-glass are provided, the latter being connected into the suction line through a valve which can be regulated to maintain any desired temperature of the suction gas. Ascertaining the quantity of liquid flowing through the regulating valve by means of the gage-glass and adding to this the quantity indicated by means of the nozzle gives the total volumetric capacity of the compressor.

To give comparative data in the shop the foregoing is all that is needed. The various parts of the system, however, may be cut into the suction line of any installation and left permanently connected. Results within 2 per cent. of the actual capacity might be expected. The apparatus can be attached also to the suction line of an absorption plant. Its value in detecting any falling off in capacity and in obtaining comparative data before and after changes, would be great.

MONDAY AFTERNOON SESSION

At the afternoon session, Monday, E. F. Mueller, of the National Bureau of Standards, presented an interesting paper on the "Physical Properties of Brine." The relation between specific gravity and other properties of brine was discussed and the need of proper tables giving the properties of both calcium-chloride and sodium-chloride brines was emphasized. As soon as accurate data are available on the thermal expansion of brines below 32 deg. F., it is the intention of the bureau to issue these tables as a bureau circular. The form of the tables and method of arrangement were indicated in the paper. An interesting digression was an explanation of the phenomena occurring on cooling a brine below its freezing point.

In a paper on "Improved Cold-Storage Methods," F. E. Matthews referred to the work being done by the Bureau of Markets, United States Department of Agriculture, to effect better world provisioning. Better distribution of foodstuffs by cold storage is a problem of vital importance. The present prodigality is illustrated by the fact that over 15 per cent. of the food is wasted before reaching storage and 19 per cent. after it is placed on the market from storage. More and better food to the consumer could be had by increasing production and lessening storage rates due to the greater volume. One of the present difficulties is the lack of uniform rates on cold-storage products, due to the varying shapes of the commodities and the waste space in piling, ranging on the average from 25 to 50 per cent. The load factor of the warehouse as well as the load factor of the refrigerating plant has a big effect on the net earnings.

The Bureau of Markets has developed a standard cost-accounting system for cold-storage warehouses. Uniformity in the various plants is important so that intelligent comparisons of results can be made for the purpose of eliminating bad practices and establishing equitable rates. Those commodities taking too much space and those paying their way can be detected and adjustments made.

The discussion centered on the prejudice against cold storage and its gradual elimination, preparation of the product before freezing, the need of a better system of getting the product from the retailer to the consumer, and the desirability of being more strict in accepting products for storage.

"Refrigeration in the Chemical Industry" was a topic on which there was some discussion. Reference was made to indirect application as in the crystallization of chemical products and direct application in the manufacture of chemicals for the preparation of dyestuffs. Cooling of chemicals by heavily icing the coils or by brine circulation through star-shaped elements was referred to specifically by Fred Ophuls, of New York City.

TUESDAY MORNING SESSION

On Tuesday morning the initial subject was "Refrigeration at Edgewood Arsenal," by J. O. Schultz. During the war the arsenal became the world's greatest toxic-gas plant. A great variety of gases in enormous quantities were made. Refrigeration was needed to cool the shells to be filled, to cool the liquid entering the shells and to de-hydrate the air used to force the liquid into the shells. Mustard oil, for example, required two tons of refrigeration for each ton of gas making. A temperature of 15 deg. was maintained in the oil cooling and shell cooling rooms. At the time of the armistice a total of 1357 tons of refrigeration had been installed.

A discussion on cooling towers was opened by J. B. Harry. Brief summaries were given of spray cooling systems and of natural ventilation and fan-draft towers and the combination tower. The highest efficiency with the least loss of water could be obtained with an atmospheric tower of proper design. For the construction of the tower, including the louvers, steel is the best material if frequently inspected and kept properly painted. Acid in the air collecting in the water and becoming concentrated in time necessitates changing the water at intervals or the introduction of alkali to neutralize the acid. The speaker told how wind shields were formed and attached to the structure in the particular tower in which he was interested. The saving in water by the use of a properly designed tower might reach 98 5 per cent. There was further discussion on the use of tile and concrete to avoid iron and the attending corrosion and the use of wood to eliminate repairs. Reference was made to the desirability of standard specifications of performance and of standard towers. With open towers the average wind velocity is a vital factor. Other points to be considered are the wetted surface, the collecting and breaking up of the water at intervals and the retardation of the drops to keep the water in the air as long as possible. Spray systems require nearly as much power as the fan tower and in addition there is considerable loss from windage.

Advantages of the high-speed ammonia compressor are less space occupied, more adaptable for direct connection to motors and higher efficiency. The cost is as much or more than that of a slow-speed machine of the same capacity owing to high-grade construction. The success of this type hinges on the discharge-valve area. With poppet valves the speed was limited if efficiency and noiseless operation were to be maintained. The feather valve had advantages and was now being introduced into the refrigerating field. Keeping the compressor properly keyed up was of great importance as the momentum increased as the square of the velocity.

MR. ORMSBY'S PAPER

"Men and Machinery in the Ice Manufacturing Plant" was the subject of a paper by Ermle S. Ormsby. The speaker expressed his belief in thoroughly good plants and in refinements tending toward economy, but maintained that the man operating the plant plays a more important part in obtaining efficiency than the machinery. Back of the man the support and confidence of the management are essential. Initiative should be encouraged, and the system of order and drive must give way to leadership and proper consideration. Poor choice of men and low salaries invariably result in low economy. A number of plants were reviewed, and those complying with the suggestions cited previously were paying dividends. In the discussion Colonel Rushton emphasized the importance of coöperation between department heads. The men should be encouraged and given every opportunity for advancement. Understudies all the way along the line are desirable, and unless absolutely necessary, outsiders should not be brought into the organization.

In a paper by John E. Starr, the point was made that although engineering is an exact science, the success of the engineer depends on his ability to reduce his conclusions to terms of cash. Obsolescence and interest on initial investment may overbalance the cost of operation. Whether to buy expensive, economical machinery or cheap machines of lower economy depends on conditions, length of service, etc. It is not so much the choice of efficient machinery as the selection of equipment that will give the best returns on the money invested.

A discussion on the relative advantages of ammonia compression versus absorption refrigerating machines for cooling water did not bring out anything new. As no specific set of conditions was assumed, the conclusions were those generally accepted. A subsequent explanation by Fred Ophuls of a new ice-making system he was perfecting proved interesting. The system is based on the fact that water can be cooled below 32 deg. F. without freezing and then at the slightest jar will flash into ice crystals. The main difficulty has been to find out why the water flashes into ice at 31.5 deg. at one time and at 29.5 deg. at another. It was discovered that the refrigerating medium has to be at a certain temperature and that the shape of the can has a bearing. The formation of loose crystals is avoided when the water is only slightly supercooled. Mr. Ophuls sketched the can, showing supercooled water coming in at one end and a continuous cake of frozen ice coming out at the other. Oil lubricated the surfaces so that the cake of ice passed along freely. It is necessary to circulate four pounds of water for each B.t.u. abstracted, but the quickness of freezing insures a large output in comparatively small space.

Reports from the various chapters brought out the suggestion that discussion of papers already presented and printed by the society would be more advantageous to the sections than the presentation of papers bordering on the commercial or of papers by the rank and file on which little time had been spent with the idea in view that they would not be printed.

The usual banquet was held Tuesday evening, and the following day was given over to the inspection of industrial plants and an automobile ride about Cincinnati.

Water-Power Bills Introduced in Congress

Water-power legislation in three different forms has been introduced in the Senate at the present extraordinary session of Congress, and the House of Representatives has passed a rule providing for the creation of another special water-power committee similar to that which worked a bill through the House at the last session of Congress, although the proposed legislation failed in the Senate as the old Congress ended, owing to the filibuster on President Wilson's foreign policies.

Representative Campbell, of Kansas, took a leading part in having the House pass the rule providing for the new committee. The rule is as follows:

> Resolved, that the Speaker of the House be, and he is hereby authorized and directed to appoint a special committee of eighteen, to whom all bills and resolutions heretofore or hereafter, introduced during the Sixty-sixth Congress pertaining to the development or utilization of water power shall be referred, notwithstanding any general rule of the House to the contrary.

The three forms in which legislation has been proposed in the Senate are as follows: A bill (Senate 152) by Senator Jones of Washington, to create a Federal Power Commission and to define its duties and powers, to provide for the improvement of navigation, for the development of water power, and for the use of the lands of the United States in relation thereto, which was referred to the Committee on Commerce; a bill (Senate 220) by Senator Walsh of Montana, to amend the act to regulate the construction of dams across navigable waters approved June 21, 1906, also the act approved June 23, 1910, and to provide for the improvement and development of waterways for the uses of interstate and foreign commerce, which was referred to the Committee on Interstate Commerce; a bill (Senate 651), by Senator Shields of Tennessee, to provide for the construction of dams across the navigable waterways of the United States, for their improvement and development, and to provide for the lease and use of public lands and the development or utilization of water power in the streams running through or adjacent to them.

The bill introduced by Senator Walsh is practically identical with the report made by the Conference Committee at the last session of Congress. It provides among other things for the issuance of permits for the development of water power for a period not exceeding fifty years.

Preliminary permits not exceeding three years may be issued for the sole purpose of maintaining priority of application during the time necessary for making examinations and surveys.

Whenever in the judgment of the commission the development of any project should be undertaken by the United States itself, the commission shall not approve any applications received from other parties.

No transfer of license or of the rights thereunder granted are allowed without the approval of the commission.

After the first twenty years of operation the licensee shall establish and maintain amortization and reserve.

The licensee shall pay to the United States reasonable annual charges in an amount to be fixed by the commission. This does not apply to such power as is used for state or municipal purposes, or to power for domestic mining or other beneficial use in projects of not more than fifty horsepower.

Combinations, agreements or understandings to limit the output of electrical energy, to restrain trade or to fix, maintain or increase prices for electrical energy are prohibited.

The licensee is required to begin the construction of the work within the time fixed, unless an extension be granted by the commission, and shall prosecute such construction in good faith, and shall from time to time thereafter construct such balance of the development as the commission shall deem necessary to meet the demands of the market. Noncompliance with this shall make the license revokable.

Upon not less than two years' notice the United States would have the right, upon or after the expiration of any license, to take over and operate the property, in which case it would be required to pay the net investment not to exceed the fair value of the property plus reasonable damages, if any. The net investment is taken as the actual original cost plus additions and betterments minus unappropriated surplus, depreciation, sinking fund or similar reserves.

If the United States does not at the expiration of the license exercise its right to take over the property, the commission is authorized to issue a new license to the original licensee upon terms consistent with the then existing laws.

Rates are left to the regulation of the state utilities commissions.

The bill introduced by Senator Jones is in many respects similar to the Walsh bill. It provides in addition that the Government will make investigations and collect data concerning the power industry, its relation to other industries, markets for power, and ascertain whether the power from government dams may be advantageously used by the United States for public purposes; such information to be made public from time to time. The licensee would be required to pay such annual charges as may be fixed by the commission solely with a view to reimbursing the United States for the actual cost of administration; such charges to be readjusted if necessary not oftener than once in two years. Further, that grants for the development or transmission of power for domestic mining or other beneficial use in projects of not more than five hundred horsepower capacity may be issued without charge. In the Walsh bill this is fifty horsepower.

Both bills provide for the taking over of the property by the Government where in the opinion of the President the safety of the United States demands such action.

The Shields bill would place the granting of permits in the hands of the Secretary of War when pertaining to navigable streams, and the Secretary of the Interior when pertaining to public lands. It has the fifty-year recapture clause the same as the other two bills, but the value of such property shall be determined by agreement between the Secretary of War and the grantee provided that no values shall be claimed for the rights granted, for good will or anticipated profits.

Representative Gillette, the Speaker of the House, announced the personnel of the new water power committee as follows:

Representatives Esch, of Wisconsin; Hamilton, of Michigan; Winslow, of Massachusetts; Sinnott, of Oregon; Smith, of Idaho; Elston, of California; Haugen, of Iowa; McLaughlin, of Michigan; Anderson, of Minnesota; Sims, of Tennessee; Doremus, of Michigan; Barclay, of Kentucky; Ferris, of Oklahoma; Taylor, of Colorado; Raker, of California; Lever, of South Carolina; Lee, of Georgia; and Candler, of Mississippi.

Investigation of Wire Rope[*]

By J. H. Griffith[†]

The Bureau of Standards for a number of years has conducted investigations having for their purpose the collection of facts concerning the strength and other properties of wire rope. The following is an abstract of some of the important data pertaining to the relative strengths of steel hoisting ropes when they are used on sheaves of different diameters, as in the case of the block and tackles for cranes and derricks.

It is shown in the dynamics of materials that a sudden application of a load, as in the case of the lifting of a weight by a crane, may cause strains that are double those experienced when it is applied gradually. On the other hand, a sudden reversal of stress may cause maximum strains three times those obtained when the reversal is made slowly. Kinetic effects may therefore be assumed to have static equivalents which in any case should not exceed the strength of the block and tackle, which will be limited, in turn, by the strength of its component parts, namely, the socket connecting cable to hook the sheaves, axles and pins. It is known, moreover, that the "quick" modulus of elasticity for metals differs only slightly from the "slow" modulus. It was assumed in conducting tests that the behavior of a number of "fall lines" and sheaves in parallel may be approximated for practical purposes by the testing of a single loop of cable over two sheaves. The tests were conducted upon plow-steel cables of six strands of 19 wires each, varying in diameter from ⅝ to 1¼-in., the sheaves being 10, 14, and 18 in. in diameter, the sizes most commonly used in practice. The following results were obtained:

Variation of Relative Strengths of Cables

Let it be supposed, first, that the strength of a cable when tested in direct tension represents a datum of 100 per cent. The mean relative strengths of cables of diameters ⅝ in. to 1¼ in., as found by actual tests, may be approximately represented by linear laws as follows: The strength on 18-in. sheaves when tested in the manner previously described varies from 96 per cent. for ⅝-in. cables to 87 per cent. for 1¼-in. cables. The corresponding values for 14-in. sheaves vary from 95 to 82 per cent. and for 10-in. sheaves from 84 to 77 per cent. The mean departures from the linear law were about 1 per cent. (±) and the maximum about 2 per cent. (±) for the different cases, except in the case of the ⅝-in. cables on 10-in. sheaves, where it was 4 per cent. higher than the law calls for. In other words, the relative strength in this case was actually 88 per cent.

On the other hand, let the datum of 100 per cent. represent the mean aggregate strengths of the component wires as found from individual tension tests. The strength of cables in direct tension by the approximate linear law varied from 85 to 88 per cent. in a range of diameters ⅝ in. to 1¼ in. inclusive. The corresponding strengths on the 18-, 14-, and 10-in. sheaves vary approximateiy from 82 to 75 per cent., 80 to 72 per cent., and 71 to 67 per cent., the mean departures in absolute values (±) being about 1½ per cent. and the maximum 3 per cent.

Cable Fracture Occurs at Tangent Point

The cables usually fractured at the point of tangency with sheaves. The sockets, pins and axles developed the strengths of the cables in each case. On the other hand, cracks developed in several of the sheaves either at hubs or rims, indicating that there were opportunities for improvement in design in this respect.

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[*] Abstract of a report by the Bureau of Standards, Pittsburgh Pennsylvania.

[†] Associate engineer physicist, Bureau of Standards.

The following table shows the average tensile strengths of the straight specimens, this being one of the datums used in the preceding comparison, together with the strengths on sheaves:

STRENGTH OF PLOW STEEL HOISTING CABLES OF SIX STRANDS OF 19 WIRES EACH

Diam. of Cable (Inches)	Average Strength Tested in Direct Tension			Tensile Strength of Cable on Sheaves		
	In Pounds	In Pounds per Sq. In.	Modulus Pounds per Sq. In.	Diam. of Sheaves Inches	Average Breaking Load In Pounds	Average Breaking Load In Pounds per Sq. In.
⅝	32,000	205,000	7,600,000	18	30,700	197,000
				14	30,900	198,009
				10	28,170	180,500
¾	50,000	221,000	8,900,000	18	45,840	202,500
				14	45,360	200,000
				10	39,840	176,000
⅞	63,000	194,000	7,600,000	18	58,400	179,500
				14	56,300	173,500
				10	51,480	158,200
1	82,000	197,500	8,900,000	18	75,540	182,000
				14	71,680	172,500
				10	65,000	156,500
1¼	132,000	209,000	6,300,000	18	110,180	176,000
				14	106,330	168,200
				10	99,080	157,000

The load in direct tension in terms of the diameter for plow-steel hoisting cables of six strands of 19 wires may be approximated by the formula $L = 83{,}000\ d^2$.

In the case of the ¾ in. cables, some tests were conducted on two samples that had been in use about five years. It was found that the strengths of the individual wires was much decreased by wear, corrosion or indentations. Many were found to be broken in service. Repeated load tests showed a considerable reduction in the resiliency, with a corresponding increase in the modulus. One specimen, in spite of its defects, bore a load of 50,000 lb., practically that of the average new specimens, whereas another failed at a load of 36,000 pounds.

RESULTS OF WIRE-ROPE TESTS

The following is a brief summary of some of the results found for the wires: (1) The elongations varied from a minimum of 1.25 per cent. to a maximum of 3 per cent., with a mean of about 2 per cent. (2) The permanent elongation and reduction were largely local, occurring mostly at the point of fracture. (3) The elastic limit of the twisted wires was about 65 per cent. (4) The average tensile strength of the wires was approximately 225,000 lb. per sq. in. (5) It was found in these tests, as in others that have been conducted on used cables, that the item of lubrication is important in lengthening the life of a cable and preventing internal corrosion. The latter increases friction of the wires and prevents a proper distribution of load through the strand. It, moreover, impairs the strength through reducing the cross-sectional area.

Planning for Power*

BY GEORGE OTIS SMITH

Director, United States Geological Survey

THERE has been, fortunately, some progress in our ideas of what is the true relation between government and business. Governmental coöperation with business is the next step. Industry itself is indeed coöperative and social by nature, and the bigger "big business" becomes the greater its need of socialization in the true sense.

These are days of "changing gears" on the big industrial machine of our country. Under the war-speed conditions we took everything on "high," regardless of either economy or safety. Now we have slowed down to "look and listen," and Business must decide which speeds are best suited for the long pull ahead. The time is therefore opportune for broad planning, and there is no more urgent need than that of a power program.

As I see it, power is the great industrial need of the day—without it the speeding up of our nation in its recent great effort to help save the world would have been impossible. Try to think of our war-time program in terms of unaided human energy; even as it was our great transportation systems almost broke under the task. The transportation of raw materials and manufactured products even in peace times calls for herculean energy—a power demand measured by more than five million continuous horsepower. Compare, if you will, the energy of the coolie crossing the mountains of central China with his backload of tea and the energy of the electric locomotive hauling copper ore from mine to smelter or ammunition from Bridgeport to New York, and you realize what electric power means in transportation.

In terms of cost, the best figures available indicate that motive power accounts for fully 30 per cent. of the expense of operating steam railroads and for about 10 per cent. of the well-managed electric railways. Aside from this difference in power cost, electric energy must be credited with the greater efficiency it makes possible.

The power element is smaller in manufacturing than in transportation, but not less important. In the making of cotton cloth about 2 per cent. of the value of the product can be charged to power, while in the production of electrolytic zinc the power cost is around 12 per cent. In general, 2 per cent. may be taken as a conservative figure for the power item in total manufacturing cost, and this may seem almost negligible, but the wider use of power in mills and shops has a larger effect than is measured by its own cost—the kilowatt-hour may double the product of the man-hour, and men cost more than kilowatts.

Electric power, as furnished from the large central stations, is favored by that happy economic law whereby the load factor works both ways. Lowering the cost of electric energy invites greater use, and greater and more diversified use permits lowered cost. That is no vicious circle; it is the virtuous upward curve of progress.

The story of wastes in our national career is not a pleasant one. Your best engineers see the trouble—the growth has been so rapid that we have given too little thought to systematic development. Wonderfully well thought-out units are scattered here and there, but these are widely separated islands in a sea of poorly planned or obsolescent plants.

You gentlemen know far better than I the wide span between your best records in large up-to-date central stations and the results obtained in smaller and often obsolescent private plants. Measured by coal burned to the kilowatt-hour the ratio is 1 to 2 or 3, or even more. Where else do we find such opportunities to cut down the coal bill? We can see even greater savings when we consider the advantages of hitching up American rivers and American coal—they work best in double harness. I believe that we are far from making full use of the water powers that lie undeveloped within easy transmission distances of our largest power markets. It is, moreover, time to count the rising costs of labor in the steam plant, where the coal miner as well as the fireman is an employee in fact, whether you see the miner's name on your payroll or not. The figures presented by the Alabama Power Co. in its comparison of steam plant with hydro-plant show the ratio of men employed as 84 to 1. Conservation of human energy calls for the immediate and full development of every water-power that is feasible.

In comparing the efficiency of the steam locomotive with that of the electric motor, I think of the switching engine as a self-contained power unit having the worst possible load factor. Here we find one ton of coal converted at the central station into the electric energy delivered to the electric motor doing the work of four tons shoveled under the boiler of the locomotive. Even with the better load factor of the passenger locomotive, there is little room for difference of opinion when we learn that the Merchants' Limited requires only half as much coal per mile between New York and New Haven as between New Haven and Boston. Can we afford to burn two tons of coal where one will pull the load?

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*Abstract from a Lecture given before the National Electric Light Association at its 42nd Annual Convention, held in Atlantic City, May 19 to 22, 1919.

The Secretary of the Interior offers a power program, and his program is inspired by a vision of future needs. He regards the almost insatiable demand for power created by war industries as foreshadowing future danger of power famine in the industrial districts of the Northeast. The signing of the armistice happily averted the power crisis that otherwise we would now be facing. Now, however, a policy of preparedness for peace expansion should be adopted.

This administrative officer's recognition of the urgency is, then, in full harmony with that definition of vision quoted by a leading engineering corporation: "Experience is the only prophecy of wise men." Secretary Lane looks upon the present relief from power famine as only temporary. In his statement to Congress he said: "In a few months, and especially in the regions mentioned, I anticipate a greatly increased demand for energy, for which present facilities are inadequate. This demand will follow the resumption of industry under the operation of normal economic laws and in the face of international competition, factors that have been largely inoperative during the war. If the country is to reap the full benefit of this returning wave of activity, it must be prepared to furnish industry and transportation with an adequate, dependable and economical power supply. Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets, maintaining at the same time the American standard of wages and living."

POWER CONDITIONS IN THE WHOLE COUNTRY

The Secretary of the Interior has asked of Congress two appropriations—one of $50,000 for continuing this power survey, undertaken by the Geological Survey, covering the whole United States, which was begun in coöperation with the Fuel Administration and at its request, and the other of $200,000 for an intensive survey of the region where power requirements are most congested. Secretary Lane proposes to study conditions in the whole country, so that we may all see the picture of present conditions and the possibilities of future growth and may be able to plan to meet that growth with the greatest economy to the nation in fuels, labor and materials. For the first fields of work, he has selected that area of maximum power density which he has chosen to call the North Atlantic Industrial District, an area that has somewhat indefinite geographic boundaries, but that is clearly defined industrially and economically. In this area, extending from the vicinity of Boston to that of Washington or Richmond, and covering 50,000 square miles, is concentrated one-fourth of the power-generating capacity of the whole country.

The need of knowing the facts is realized when we try to measure even present power requirements, not to mention future demands. The Boston-Washington region uses 600,000,000 kw.-hr. a month, most of it derived from coal. The central stations alone consume fully 10,000,000 tons of coal a year; add to this, say, 25,000,000 tons for the railroads in this area, and we begin to appreciate in a general way the part coal plays as a source of motive energy.

In conducting these inquiries the Geological Survey must of course rely upon the coöperation of the electrical industry and, as was expected, this coöperation has been almost universally given, the Survey's analysis of February operations representing over 92 per cent. of the output of the country. You will realize that a monthly report of the country's power output makes the most sensitive of business barometers, for unlike coal and steel records it is unaffected either by any carried-over surplus or by orders for future use.

I trust, too, that this coöperation is not one-sided, for the Government bureau is in a position to assist your industry in many ways. I may mention one way: The manufacturer seeking a location for a new plant comes to the Geological Survey with his statement of requirements in raw materials, transportation, power and labor. From the knowledge obtained from you gentlemen, this Government bureau is able to suggest localities where he will be likely to get power at reasonable rates and to refer him to several power companies that can meet his requirements. The average manufacturer seeking power is today very much in the dark, and any clearing house where the industrial man can be introduced to the power man and where the only wish is to do both a service must be of real value to the industry.

PICTURE OF THE SUPER-POWER SYSTEM

My own picture of the super-power system that would effect the economies demanded by the rapid growth of this industrial region includes a multiple transmission line of high voltage with its thousands of steel towers extending from Boston through our Eastern States, crossing the Connecticut near Springfield, the Hudson at Poughkeepsie, the Delaware near Easton, and the Susquehanna below York, and so on to Washington and Richmond. Into this unified system large-unit steam-electric stations at tide-water and near the mine mouths and hydro-electric stations—20 or more—at old and new sites would deliver energy as required, and from this great power main would flow the energy to serve a score of railroads, hundreds of public-service companies, thousands of manufacturing plants and millions of homes.

As one of my engineer friends remarks, this project would appear a "large order," and at first it staggers the imagination, but such a super-power line extending from Boston to Washington cannot be termed only a dream. Secretary Lane has pointed out that in his own State of California there are systems of electric transmission comparable with this in length if not in capacity. If you take your map of the United States and make the West move East—which I admit is contrary to human experience—you can take one end of an existing trunk power line, which is at Tonopah, Nev., and lay that on Boston, and then the other end of the line, which is actually at Yuma, Ariz., and can be placed at Norfolk, Va. What we dream for the East exists in the West, where the extreme tentacles of one system of interconnected power plants now have a reach of nearly 500 miles.

As a nation bounded by the two oceans we own 55 per cent. of the world's coal, yet the tonnage remaining in the great producing fields of the East is so limited as to make coal saving a topic deserving the best thought of those concerned in power generation. And coal from the more distant fields will be more expensive coal.

CHEAP POWER AN ASSET OF FIRST RANK

Meeting the need for cheap power, however, has far more than a local significance. Cheap power is already an asset of the first rank to any country in the international contest for world markets. With the strategy of war fresh in mind, we may look upon this Atlantic Seaboard Industrial Region as the American front trench in the commercial rivalry among nations. This is the reason that Secretary Lane, while asking Congress for a general survey of the power resources of the whole country, wishes also to make this more intensive study where the need is greatest and most urgent.

America's comrades in arms, France and Great Britain, are wide awake to their peace needs. They recognize cheap power as a key to the markets of the world, although the reference in British reports to the electrical industry as a "key industry" doubtless means that electric power is the keystone in the national industrial arch. Already in England, five official commissions have submitted reports on the question of power development, in which they emphasize the national importance of cheap power as a vital requirement. They consider electric power as essential as labor and material in economic production. They reiterate that in England less power is used by certain industries than is used by similar industries in the United States, where the larger net output per operative employed and the higher rates of wages show the advantage both to capital and to labor.

In working out their national program these British commissions condemn the existing provincial and parochial systems of generating and distributing electricity and urge a centralized and unified power system as the only method of conserving their coal supply by getting the fullest value from every ton consumed and thus furnishing cheaper power to the industries, large and small.

Our interest as citizens in these plans for cheaper energy is far more than a commercial interest. Public service is a term that has come to attach itself to your industry, and not without reason. The organization of the nation's business to obtain the lowest costs is distinctly a matter of public service, in which corporation and Government bureau may well join efforts, but success in this organization of industry is not to be measured in dividends alone. Tomorrow prosperity must mean profit sharing on a thoroughgoing scale, in which we shall all receive in proportion as we have served. So the industrial program which emphasizes mechanical power is the most effective assurance of better conditions for all who work in this busy world of ours. To improve living conditions for all our citizens must be the aim of those to whom is given the privilege of leadership in industry. Secretary Lane has said that "upon our shoulders rests the burden of proving that free government can live. America is the ultimate citadel of human liberty."

Fusing Potential Transformers

According to the report of the Meter Committee of the National Electric Light Association, presented at the 42nd annual convention, question has arisen at different times in committee meetings as to the practice of fusing potential transformers used with watt-hour meters.

The fuses used on potential transformers to serve the purpose as a fuse are liable to be light and fragile. The loss of a fuse either mechanically or electrically means the loss of the element on one phase. With a load of inductive characteristics, that particular phase might be carrying a relatively small percentage of the total load. For this reason the blown fuse might go undetected for a considerable period with a consequent significant loss of revenue.

Question arises, therefore, as to the desirability of eliminating the fuses on the potential transformers. A survey by the committee itself indicated that 80 per cent. of the companies represented use potential transformers unfused on meters on circuits of 6600 volts or less.

The suggested use of a limiting resistance in the primary in place of the fuses is a questionable practice from the standpoint of introducing possible errors.

Authority to impose a 10 per cent. surcharge on its electric rates beginning May 1, has been granted the Northern California Power Co., consolidated, operating in Shasta, Tehama, Glenn, Butte, Colusa, Yolo and Trinity counties, by the state railroad commission. The company had asked for increases ranging from 14 to 35 per cent. The surcharge will not apply to those portions of Butte and Colusa Counties where the company is in competition with the Pacific Gas and Electric Co.

Personals

Paul T. Buckler has been released from service in the Navy and is back at his old job in the New York City office of the Detroit Stoker Co.

Frank J. Tone has been elected president of the Carborundum Co., Niagara Falls., N. Y., to succeed the late Frank W. Haskell. George R. Rayner has been made vice president to succeed R. B. Mellon, of Pittsburgh. F. H. Manley retains the office of treasurer.

M. H. Jones, who has been connected with the Westinghouse Electric and Manufacturing Co. for the last fifteen years as assistant to the manager of the Philadelphia district, has resigned to become sales manager of the Standard Electric and Elevator Co., of Baltimore.

Joseph W. Greves, who was connected with the Otis Elevator Co. for a number of years, and during the war was an instructor in the machine department of the Submarine Boat Corp., at Port Newark, N. J., has accepted the position of superintendent and chief engineer of the new Elks Building, Jersey City, N. J.

John E. Muhlfeld has resigned as president of the Pulverized Fuel Equipment Corp. and has associated with him several other engineers and formed the Railway and Industrial Engineers, Inc., with offices at 25 Broad St., New York City, to act as consulting and advisory engineers to bankers, railroads and industrial corporations. Mr. Muhlfeld has, for the last five years, been specializing in the development of the "Lopulco" system for burning pulverized fuel in locomotives, stationary boilers and metallurgical and chemical furnaces. He will retain his interests in and remain a director of the Pulverized Fuel Equipment Corporation.

Colonel Douglas I. McKay has been elected president of the Pulverized Fuel Equipment Corp., of New York City, to succeed John E. Muhlfeld, who retired to return to consulting engineering practice. Colonel McKay has been engaged in war work since July, 1917. At that time he was commissioned major in the Ordnance Reserve Corps in charge of the Raw Materials Branch of the Gun Division. In January, 1918, he was promoted to lieutenant colonel of the National Army and appointed assistant director of Purchase and Supply.. He was subsequently promoted to colonel and continued in this capacity until he returned to civil life after the armistice was signed. He was formerly first deputy police commissioner and later was police commissioner of New York City. After he resigned the commissionership he became assistant to the president of J. G. White & Co., Inc., and two years later was elected vice president and director, which position he held at the time he entered the Army service. In addition to being president of the Pulverized Fuel Equipment Corp., he is vice president and director of the Chemical Foundation, Inc., director of the International Agricultural Corp. and director of the Botany Worsted Mills.

Engineering Affairs

Indiana State Association, N. A. S. E. annual convention will be held at Terre Haute, June 26-28.

The National Electric Light Association, Iowa Section, will hold its next convention at Colfax, Iowa, June 18-20.

The Society of Automotive Engineers will hold its spring meeting at Ottawa Beach, Mich., June 23-27.

The American Association of Engineers, New York Chapter, has elected the following officers: President, Alexander Potter; first vice president, J. C. Patterson; second vice president, Maurice Griest; treasurer, Hugh C. Jackson; secretary, E. B. Miller.

Taunton Association No. 25, N. A. S. E., of Massachusetts, held its twenty-third anniversary on Saturday, May 24. The attendance was unexpectedly large, among those present being many prominent association members. There were interesting talks and a good entertainment. Refreshments were served.

Springfield Council No. 23, Universal Craftsmen, Council of Engineers, was instituted at Springfield, Mass., on May 1, at the Engineers' Hall. There were upwards of sixty charter members. Walter H. Damon, chairman of the organizing committee, was elected worthy chief.

The National District Heating Association will hold a Victory convention at the William Penn Hotel, Pittsburgh, Penn., June 10-13. At the same time and in the same hotel the American Society of Heating and Ventilating Engineers will hold its summer convention. Wednesday's (June 11) session will be a joint meeting of the two associations. A fine program has been laid out for all the meetings, and it is anticipated that this will be the largest and best convention the association has ever held.

Miscellaneous News

The Bureau of Mines, Department of the Interior, will formally dedicate its new million-dollar laboratories and workshops in Pittsburgh, Penn., with fitting ceremonies Sept. 29-Oct. 1. High Government officials, together with the governors of the principal mining states, and leaders in the mining industries and mining organizations will take part in the dedicatory ceremonies. A spectacular feature of the dedication will be a great, national safety-first meet, with teams of miners from all over the country competing for prizes. Visitors will be invited to the electrical and mechanical workshops and laboratories of the Bureau and also to the petroleum, gas and coal laboratories, the testing gallery of the mine safety section, and the industrial gas-mask division. An exhibit representing the mining and metallurgical industries of the country. Visits will be made to typical Pittsburgh industries.

An Anniversary Dinner for John A. Stevens, of Lowell, Mass., in recognition of the completion of the first ten years of successful business, was given to him by his associate engineers and assistants at the Hotel Thorndike in Boston, Mass., Saturday evening, May 17. About forty members of the organization were present, and an informal reception was given to Mr. and Mrs. Stevens before the dinner. The menus, or "Fundamental Data," as they were called, were written in engineering terms and included such novelties as "extra heavy bi-valves," "assorted bolts and nuts" and "turbine oil." These menu programs were very attractively and appropriately designed, the front cover illustrating one of the first plants built in 1909 and a very large proposed super power house, the design of which was recently made in Mr. Stevens' office. There were some after-dinner speeches and at the conclusion Mr. Stevens was presented with a loving cup on behalf of the members of the organization.

Business Items

The Wellman-Seaver-Morgan Co. announces the opening of an Atlanta office at 318 Hurt Building, in charge of E. R. Kenner.

The Leeds & Northrup Co., Philadelphia, Penn., has opened a pyrometer sales and service department at 1304 Monadnock Block, Chicago, with Henry Brewer in charge.

The Hill Pump Valve Co., of Chicago, Ill., has purchased a tract with frontage on Belmont and Knox Avenues, upon which it will erect a new $500,000 plant intended to be as modern and well equipped factory as there is in the country.

The Dominion Asbestos and Rubber Corp., of New York City, has recently opened branch offices in Albany, N. Y., Atlanta, Ga., and Allentown, Penn. The capital stock of the company was recently increased, and with the cessation of hostilities the company is now able to devote its energies to the sale of its products in the industrial field.

Trade Catalogs

The Buffalo Forge Co., Buffalo, N. Y., has issued its catalog Section No. 400, on "Fans, Blowers and Exhausters," fully describing and illustrating the design and structural details of these company products.

The Superheater and Engineering Co., New York City, has issued an 11-page bulletin on "Dravo Superheaters." An instructive bulletin showing various applications of the Dravo superheater with introductory page on the "Conservation of Fuel."

"Davison Burners" is the title of a 20-page catalog just issued by the N. C. Davison Gas Burner and Welding Co., of Pittsburgh, Penn. As well as a full description of the various burners, the booklet contains some useful information on steam boilers, tables showing gravity of fuel oils, specific heats, and rule for figuring B.t.u.'s in fuel oil.

The Locomotive Superheater Co., of New York City, has just issued an 8-page Bulletin T-2 entitled "Superheaters for Stationary Power Plants." The bulletin illustrates and tells how the Elesco superheater is the theoretically correct and practical method of securing the advantages of the use of superheated steam in stationary boilers. A copy may be had free upon request.

"Murray Steam Power Plants" is the title of a 95-page catalog No. 85, just issued by the Murray Iron Works Co., Burlington, Iowa. This catalog contains 85 illustrations with information on different types of boilers and Corliss engines, marine engines, pumping engines, governors, valve gears and other boiler and engine accessories; also table of horsepowers.

The Metal and Thermit Corp., New York City, has issued a folder entitled "How Thermit Healed My Broken Jaw," which illustrates the operations involved in making a Thermit weld on the 13½-ton broken upper jaw of an alligator shear used by the Jos. Joseph & Bros. Co., Modena, Penn. The break welded was 80 in. in length and varied from 4½ to 23 in. in thickness.

The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has just issued a 62-page booklet No. 137 entitled "Works and Products," presenting in condensed form a description of the company and its capacity for producing a great variety of machinery, including the largest and most powerful prime movers and electrical machinery in the world; also detailed information with reference to the company's plants and products.

The Tide Water Oil Co., New York City, has recently published an interesting 46-page booklet on "Fuel Oil." In addition to the material on the various kinds and uses of fuel and crude oils, details are given regarding the use of fuel oil in metallurgical furnaces for either ferrous or non-ferrous metals, ceramic work in its various branches, gas manufacture or enrichment of water gas, steam for power, Diesel or other internal-combustion engines. The booklet is intended to be of service not only to the nontechnical executives and plant managers, but also to the plant engineer. It is well illustrated.

The C. H. Wheeler Manufacturing Co., Philadelphia, Penn., has just issued its 1919 catalog containing 191 pages, and entitled "Condensers and Condensing." It contains 124 illustrations and a lot of useful information on different types of vacuum pumps, centrifugal pumps, direct-acting steam pumps, thermodynamics of condensers, jet and barometric condensers, surface condensers, water-cooling towers, economy of high vacuum, feed-water heaters, engines, marine equipment, etc., as well as tables on the properties of saturated steam from 32 to 212 deg. F., a relative humidity table, and one on mean barometric pressures corresponding to altitudes from 100 to 4900 ft. above sea level.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8 05@8 35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.75@3.25
Philadelphia, gross tons	4 27@4 95	5 95@5 50
New York, gross tons	4 62@5 29	5.29@5 85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7 55

Pocahontas and New River are quoted at $4 70 @5 25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6 05	$7 90	Pea	4.90	6.65
Egg	5 95	7 80	Buckwheat	3.40	5.15
Stove	6 20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2 90 @ $3 25	$2 95 @ $3 50
Cambria County (good grades)	2 75 @ 2 95	2 95 @ 3 25
Clearfield County	2 50 @ 2 75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2 75 @ 2.95
Quemahoning	2 65 @ 2 85	2.95 @ 3 10
Somerset County (best grades)	2 65 @ 2 85	2.95 @ 3 10
Somerset County (poorer grades)	2 00 @ 2.35	2.50 @ 2 75
Western Maryland	2 25 @ 2 75	2.50 @ 2 75
Fairmont	2 00 @ 2.25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2.25 @ 2.40
Greensburg	2 25 @ 2 35	2 35 @ 2 60
Westmoreland	2 60 @ 2 75	2 60 @ 2 75
Westmoreland run-of-mine	2.35 @ 2.60	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7 80	Buckwheat	$3.40	$4 45
Egg	5.95	7 80	Rice	2.75	3.65
Stove	6 20	8 05	Boiler	2.50	3 50
Nut	6 30	8.15	Barley	2.25	3.15
Pea	4.90	6 50	Culm	1 25	2 15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2 55@$2.75	$3.25
Mine-run	2 35@ 2 50	3 00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2 45	$2 75	$2 40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3 40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

	Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2 00@2 25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump		2 30	
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; other rates 92½c

New Construction

PROPOSED WORK

Conn., Bridgeport—The Nichols Underwear Corp., James St. and Linen Ave., plans to build a 1-story, 26 x 26 ft. power plant in connection with the 2-story, 65 x 190 ft. factory which it plans to build on Benham Ave. Total estimated cost, $100,000. Fletcher-Thompson, Inc., 1089 Broad St., Engr.

Conn., Hartford—Libby, McNeil & Libby, 252 Asylum St., will soon award the contract for the construction of a 3-story, 50 x 112 ft. cold storage plant on Edwards St. Estimated cost, $60,000. P. Larmon, c/o Swift & Co., Union Stock Yards, Chicago, Ill., Engrs. Noted Feb. 4.

N. Y., New York—The Mt. Sinai Hospital, 100th St. and Madison Ave., will install a steam heating plant in the 2-story, 100 x 120 ft. auditorium which it plans to build on 99th St. east of 5th Ave. Total estimated cost, $150,000. A. W. Brunner, 101 Park Ave., arch.

Penn., Erie—The county will install a 1 and 2-story, 65 x 175 ft. power house in connection with the 2-story, 200 x 390 ft. home which it plans to build. Estimated cost, $200,000. Crooks & Cooley, Jones Law Bldg., Pittsburgh, Arch.

Penn., Mercer—The Elliott-Blair Steel Co., East Market St., is in the market for a 10 h.p., 3-phase, 220-volt motor. E. Elliott, Mgr.

Penn., Scranton—M. Maloney, Land Title Bldg., Philadelphia, will install a steam heating plant to heat the 32 houses which he plans to build on Adams Ave. Total estimated cost, $130,000. J. J. Howley, Traders Bank Bldg., Scranton, Arch.

Md., Baltimore—C. L. Reeder, Arch., 300 Park Ave., is receiving bids for installing new motors, electric lighting and wiring and electric elevators for the W. F. Assau Canning Co., Boston and Streeper St. Estimated cost, $10,000.

Fla., Sarasota—The City Council will receive bids until June 30 for the construction of a power plant, to include connecting pumps, wells, tower or reservoir, mains, hydrants, fittings and connections, etc. W. A. Ginn, Sanford, Consult. Engr.

Fla., Sarasota—The city will receive bids until June 9 for supplying equipment and material necessary for a water and electric lighting plant and system; to consist of 3 internal combustion fuel engines; two, 150 h.p. each; one 100 h.p., with D. C. generators, exciters to correspond to the given power; 2 rotary pumps, 1 right, 1 left, capacity 500 g.p.m. against 330 ft. head, D.C. to motors, equal to the lift with 25 p.c. overload, calculated as a factor of safety; 2 air compressors, 1 motor driven, 1 engine driven, single capacity equal to 100 cu.ft. per minute, pressure head 250 lbs. per sq. in., automatic cut-off; 2 air tanks, 4½ x 8 ft., double riveted, tested to 230 lbs compression; gages, stop cocks, connections, air and water, some radiation to offices and connections for circulation 24 ft. above the engine base, to radiate from engine water jackets; file with bids 3 complete detail drawings showing base, longitudinal and transverse sections for base of all machines, all water, fuel lubricants, oil-action and connections, air and all connections, pumps, all centers (e ways) sections, discharge and foundation connections and switchboard. W. A. Ginn, Sanford, Consult. Engr.

S. C., Eau Clair (Columbia P. O.)—The Town Council plans election soon to vote on $40,000 bonds for the construction of a waterworks system, to include pumping station, filters, etc. W. C. McCreight, Union National Bank Bldg., Columbia, Clk.

Ohio, Oxford—The Trustees of the Miami University will receive bids until June 14 for an engine and generator together with switchboard changes, wiring and piping connections, for the central heating and lighting plant. W. G. Franz, 1703 Union Trade Bldg., Cincinnati, Consult. Engr.

Ohio, Piqua—The French Oil Machinery Co. is having plans prepared by the J. J. Wernette Engineering Co., Engrs., 441 Houseman Bldg., Grand Rapids, Mich., for the construction of an addition to its power plant.

Ohio, Piqua—The Orr Felt & Blanket Co. is having plans prepared by the J. J. Wernette Engineering Co., Engrs., 441 Houseman Bldg., Grand Rapids, Mich., for the construction of a complete 84 x 150 ft., 1,000 h.p. plant.

Ohio, Sandusky—The Macultivator Co., Sandusky Apartments, will be in the market about July 1 for boilers over 50 h.p., engines and belt for power plant, drilling machines, electric and hand, dynamos for power plant and lathes, etc. C. McCarthy, Gen. Mgr.

Ind., Crawfordsville—The Standard Brick Co. is in the market for power plant machinery and pumps for power plant.

Mich., Detroit—The Board of Education, 50 Broadway, will install a Plenum heating system and 1 boiler in the school which it plans to build on Georgia Ave., between Helen and Concord Ave., to be known as the Theodore Roosevelt School; also a Plenum heating system with 1 boiler in the 133 x 211 ft. standard design school No. 1055, which it plans to build on Georgia Ave. Malcomson & Higginbotham, 404 Moffat Bldg., Arch.

Mich., Detroit—The Oakman Boulevard Theatre Co., 9 Fort St., West, will install a heating plant, steam heating apparatus, motors and fans in the theatre, stores, etc., which it plans to build on Oakman Blvd. and Glendale Ave. Total estimated cost, $350,000. C. H. Crane and E. G. Kiehler, Dime Bank Bldg., Archts.

Mich., Detroit—The Liberty Motor Car Co., foot of Lycaste St., will install a 40 x 60 ft. heating plant, in connection with the plant which it plans to build on Charlevoix Ave. Austin & Co., 1954 Penobscot Bldg., Engr.

Mich., Detroit—St. Theresa Parish, c/o Van Leyen, Schilling & Keough, Arch., 1121 Union Trust Bldg., will install a steam heating plant in the 2-story, 70 x 180 ft. school which it plans to build on Grand River and Quincy Ave. Total estimated cost, $130,000.

Mich., Grand Rapids—The American Laundry Works, Division Ave., is having plans prepared by the J. J. Wernette Engineering Co., Engrs., 441 Houseman Bldg., for installing an engine and power plant.

Mich., Grand Rapids—The Nichols & Cox Lumber Co., 1069 Godfrey Ave., S. W., is in the market for a Union vacuum pump. W. Kemp, Ch. Engr.

Mich., Grand Rapids—The Regents Theatre Co., Woodward Ave., will install a steam heating plant and motors in the 2 story, 100 x 152 ft. theatre which it plans to build on Monroe Ave. Total estimated cost, $300,000. C. H. Crane and E. G. Kiehler, Dime Bank Bldg., Detroit, Arch.

Okla., Beggs—The Board of Trustees will receive bids until June 18 for installing a 7 x 8 ft. triplex pump and a 25 h.p. electric motor. W. K. Enoch, Town Clk.

Cal., Calexico—The city plans to install additional pumping facilities. Estimated cost, $20,000. P. B. Steintorff, City Clk.

Cal., California—The Bureau of Yards & Docks, Washington, D. C., plans to build a power plant at the Navy Coaling Yard, here. Estimated cost, $20,000.

Cal., Los Angeles—The Board of Public Service Commission, 615 South Olive St., plan election soon to vote on $13,500,000 bonds, $2,500,000 to be used for constructing power plant No. 2 in San Francisquito canyon and power development in the Owens River Gorge, and $11,000,000 for purchasing the distributing system in Los Angeles owned by the Southern California Edison Co. E. F. Scattergood, 615 South Olive St., Engr.

Cal., Los Angeles—J. P. Vroman, secy. of the Board of Public Service Commission, will receive bids until June 10 for furnishing valves and fittings for special penstock for power plant No. 2 in San Francisquito canyon. W. Mulholland, 645 South Olive St., Engr.

CONTRACTS AWARDED

Vt., Vernon—The Connecticut River Power Co., Osgood Bradley Bldg., Worcester, Mass., will build a 65 x 110 ft. addition to its power plant on the Connecticut River and install 2 additional electrical units of 5000 k.w. capacity. Total estimated cost, $1,000,000. Work will be done by day labor.

Mass., Boston—The Quincy Cold Storage Co. has awarded the contract for the construction of a 10-story, 60 x 180 ft. cold storage plant on the India Wharf, to the B. Fox, Inc., 15 Exchange St. Estimated cost, $500,000.

Conn., New Britain—Landers, Frary & Clark, Commercial St., has awarded the contract for the construction of a 14 x 23 ft. pump house and tank, to J. H. Grozier Co., 721 Main St., Hartford. Estimated cost, $14,000.

N. Y., Ogdensburg—The State Hospital Commission, Albany, received lowest three bids for boiler breeching at the St. Lawrence State Hospital, from Mansfield & Savage, 135 Williams St., New York City, $6,999; Murtagh & Reddington Co., 26 Pleasant St., Rochester, N. Y., $9,100; Austin Heating Co., 121 West 42nd St., New York City, $9,725. Noted Feb. 4.

N. Y., Syracuse—H. C. Allen, City Engr., received lowest three bids for installing heating and ventilating systems in Prescott School, from J. R. Sheehan Co., 16 South Center St., Schenectady, $43,213; W. B. Goldie, 274 James St., $45,915; E. Joy & Co., 133 Market St., $53,934.

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing steam distributing systems at the Navy Yard here (work complete), from Almiral & Co., 1 Dominick St., New York City, $212,318; Lynch & Woodward, 287 Atlantic Ave., Boston, Mass., $262,576; H. E. Crook Co., 28 Light St., Baltimore, Md., $272,465. Specification No. 3876.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing 3 motor generator sets and switchboard at the Submarine Base here (work complete), from the General Electric Co., River Road, Schenectady, N. Y., $43,750; Westinghouse Electric & Manufacturing Co., 803 Hibbs Bldg., Washington, D. C., $47,133. Specification No. 3872.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing a high pressure air and water system at the Submarine Base here (work complete) from Almiral & Co., 1 Dominick St., New York City, $12,200; Noland Clifford Co., 330 28th St., Newport News, Va., $12,781; Newport Contracting & Engineering Co., Silsby Bldg., Newport News, Va., $16,175. Specification No. 3883. Noted May 20.

Wis., Sheboygan—Armour & Co., c/o A. Lotz, Chicago, has awarded the contract for the construction of a 1-story, 60 x 150 ft. cooler and warehouse on South Water St., to J. L. Carnegie, 189 West Madison St., Chicago, Ill. A cooling system will be installed in same. Total estimated cost, $55,000. Noted Apr. 15.

N. D., Devils Lake—R. E. Cobb Co., 3rd and Cedar St., St. Paul, Minn., has awarded the contract for the construction of a cold storage and meat plant, here, to H. C. Strucker, 405 Dakota Bldg., St. Paul, Minn. Estimated cost, $60,000.

Man., Winnipeg—The Department of Public Works, Ottawa, Ont., has awarded the contract for the construction of a 1-story, 110 x 122 ft. extension to the power house and laundry at the Military Hospital at Tuxedo, to Carter, Halls, Aldinger Co., 1010 Union Bank Bldg., Winnipeg. Estimated cost, $145,529. Noted Apr. 8.

P. I., Cavite—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing power plant equipment for radio purposes, at the Naval Radio Station, here (1) net price and time for the entire work complete in accordance with the drawings and specifications, including traveling expenses of the supervising erector; (1a) net price per day for the services of supervising erector; (2) net price and time for 2 boilers to superheaters and accessories, fuel oil pumping equipment, and oil burning sets, flue and stack with supports, traveling expenses of the supervising erector for the above equipment; (2a) net price per day for the service of supervising erector; (3) net price and time for 2 turbo-alternators with accessories, 2 exciters sets, switchboard and equipment; traveling expenses of the supervising erector for above equipment; (3a) net price per day for service of a supervising erector; (4) net price and time for condensers with air ejectors and accessories, condensate pumps, cir. pumps, boiler feed pumps, traveling expenses of a supervising erector of the above equipment; (4a) net price per day for the services of supervising erector; (5) amount to be deducted from (4), if the services of a supervising erector are not required, from

Babcock & Wilcox Co., North American Building, Philadelphia, Penn., (2) $31,721, (2a) $12 per day; General Electric Co., River Road, Schenectady, N. Y., (3) $47,150, alternate $47,400; (3a) $20 per day; Westinghouse Electric & Manufacturing Co., Southern Bldg., Washington, D. C., (3) $47,366 (50 days); (3a) $25 per day; (4) $32,768, (150 days); (4a) $25 per day; (5) $1875. Specification No. 3871.

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Turn to pages 71 to 80

The SEARCHLIGHT SECTION of POWER is the "opportunity" centre of the power plant field. If you don't find what you want in this issue an advertisement in the next will probably get it for you.

PRICES - MATERIALS - SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE –

Fire	50-Ft. Lengths
Underwriters' 2½-in	70c per ft
Common, 2½-in	40–10%

Air	First Grade	Second Grade	Third Grade
¾-in. per ft	$0 45	$0 30	$0 20

Steam—Discounts from List

First grade...... 35% Second grade...... 45% Third grade.... 50%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	65%	Best grade	40%
Standard	50–10%		

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	45%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	35%	35%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound.

Rubber and duck for low-pressure steam	$0 90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1 60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1 20
Asbestos wick, ½- and 1-lb. balls	85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1 30	3½-in.	1 05

85% magnesia high pressure		List
For low-pressure heating and return lines	4-ply	58% off
	3-ply	60% off
	2-ply	62% off

GREASES –Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5¼	7	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	8½	20
Axle	4½	6	4	4 75	4	5¼
Gear	4½	9	4½	7.5	8½	8
Car journal	22(gal.)	21 (gal.)	3½	4.9	8½	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11 00 to 13 00	13 00	14 00	11 00 to 14 00
Colored mixed	8.50 to 12.00	12 00	11.00	9.50 to 12 00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13¼ x 13¼	13¼ x 20½
Cleveland	$52.00	$58 00
Chicago	41 00	43 50

LINSEED OIL—These prices are per gallon:

	New York		Cleveland	Chicago		St. Louis
	Current	One Year Ago	Current	Current	One Year Ago	Current
Raw in barrels	$1 63	$1 55	$1.74	$1 78	$1 65	$1.69
5-gal cans	1 76	1.65	1 90	1.98	1.75	1.75

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb keg	13 00	14 50	11.25	11.50	13 00	10.50
25- and 50-lb. kegs	13.25	14 75	11.50	11 75	13 25	10.75
12½-lb keg	13 50	15 00	11.75	11 00	13 50	11.00
1-lb. cans	15.00	16.50	13 25	13 00	15 00	13.00
5-lb cans	16 00	17 50	13 25	13 50	16 00	13.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

AMMONIA—Price per pound in St. Louis for 26 deg U. S. P., 100-lb. car boys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel 7/16 and smaller	40%	60–5%	45%
Tinned	30%	60–5%	40%

Boiler rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$6.35 Cleveland...$4.75 Chicago...$4.72 Pittsburgh... 4.65

Structual rivets, same sizes:

New York....$6.25 Cleveland...$4 85 Chicago...$4 82 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00	at Chester, Penn.
Chrome cement	net ton	65.00	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48	at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50	at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90	at Chester, Penn.
Silica brick	net ton	45–55	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $41–$44; silica, $46, $50-$15.50 magnesite, $80-$85; chrome, $80-$90.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL — Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	90.00	79.00	90.00	75.00	90 00
Commercial	42 00	50.00	18 50	30.00	15.00	30 00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15 00
Cleveland	20 00	15 00
Chicago	16.50	15.00

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 15c. per lb.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft	$5.82	$5.17	$4 55	$5.17
7 in. by 30 ft	7.65	6.85	6.10	6.85
7 in. by 35 ft	11.10	10 00	8 95	10 00
8 in. by 35 ft	12 65	11 35	10 10	11 35
7 in. by 40 ft	12.85	11.50	10 20	11.50
8 in. by 45 ft	18.90	16 90	15 00	16 90
8 in. by 50 ft	22.65	20.30	18 00	20 30

10c. higher freight rates on account of double loads.

For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft	$9.00
12-in. butts, 6-in. tops, length 30-40 ft	11.50
12-in. butts, 6-in. tops, length 41-50 ft	12.50
14-in. butts, 6-in. tops, length 51-60 ft	21.00
14-in. butts, 6-in. tops, length 61-71 ft	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

	Steel			Iron	
Inches	Black	Galvanized	Inches	Black	Galvanized
BUTT WELD					
⅛, ¼, and ⅜	50½%	24%	¾ to 1½	39½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			
LAP WELD					
2	50½%	38%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%
BUTT WELD, EXTRA STRONG PLAIN ENDS					
⅛, ¼ and ⅜	46½%	29%	¾ to 1½	39½%	24½%
½	51½%	39%			
¾ to 1½	55½%	43%			
LAP WELD, EXTRA STRONG PLAIN ENDS					
2	48%	37½%	2	33½%	20½%
2½ to 4	51%	40½%	2½ to 4	35½%	23½%
4½ to 6	50%	39¼%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	47%	31%	46½%	31 %	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	42½%	27½%	51½%	41%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%. Cast iron, standard sizes, 10% off

BOILER TUBES—The following are the prices for [illegible] f.o.b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	40½	3½ to 4½ in.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	[illegible]	[illegible]
1¾ to 2 in.	19½	[illegible]	[illegible]
		[illegible]	[illegible]

Standard Commercial Seamless Boiler Tubes, Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$[illegible]	1¾ in.	$[illegible]
1¼ in.	[illegible]	2 to 2½ in.	177
1½ in.	[illegible]	2¾ to 3¼ in.	167
1¾ in.	[illegible]	4 in.	187
		3½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, to be Noted in Next Issue

ARMORED CABLE—

B & S Size	Two Cond. M Ft	Three Cond. M Ft	Two Cond. Lead M Ft	Three Cond. Lead M Ft
No. 14 solid	$104 00	$138 00	$164 00	$222 00
No. 12 solid	[illegible] 00	170 00	211 00	290 00
No. 10 solid	185 00	235 00	255 00	325 00
No. 8 stranded.....	235 00	325 00	345 00	450 00
No. 6 stranded	370 00	472 00	625 00	

From the above lists discounts are:

Less than coil lots	Net List
Coils to 1,000 ft	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready:

	Each, Net
Less than 12	$0 40
12 to 50	38
50 to 125 (bbl.) .	35
125 (bbl.) or over	32

CONDUITS ELBOWS AND COUPLINGS Following are warehouse net prices per 1000 ft. for conduit and per 100 ft. for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In	Black 1,000 Ft. and Over	Galvanized 1,000 Ft and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜ ..	$71 15	$76 25	$17 04	$18 18	$5.38	$5.74
½....	71.15	76.25	17.04	18.18	6 28	6 70
¾....	93.96	100.86	22.43	23 93	8.97	9 57
1	138.39	149.09	33 19	35 41	11 66	12 44
1¼	187.91	201.71	42 62	45.31	16 10	17 12
1½	224.68	241 18	56 82	60 62	19 89	21.15
2	302.29	324 49	104 17	110 77	26 52	28 20
2½	477.95	513.05	170 46	181 26	37 88	40 28
3	625.00	670.91	454 56	483 36	56 82	60 42
3½	779.24	834.44	1,003.82	1,067 42	75 76	80 56
4	945.03	1,010.43	1,160.08	1,233.57	94 70	100.70

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
7/32	250	$0 05½	
¼	250	06	
⅜	250	.09	
½	200	.12	Coils... . 60% off
⅝	200	.15	Less coils, 50% off
¾	150	18	
1	100	.25	
1¼	100	.33	
1½	Odd lengths	40	
2	Odd lengths	55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.............	$0.11	T. P. to D. P. S. B..........	$0 24
D. P. M. L.	.18	T. P. to D. P. T. B...	38
T. P. M. L	.26	T. P. S. B	33
D. P. S. B	19	T. P. D. B	54
D. P. D. B	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L	$0 33	$0 84	$1 68
T. P. M. L ..	.48	1 20	2 40
D. P. S. B .. .	.42	1 05	
T. P. S. B	.81	1.80	..
D. P. D. B. ..	78	2 10	
T. P. D. B......... .	1 35	3 60	
T. P. to D. P. D. B	90	2.52	

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted..........	$18 00
No. 16 cotton twisted	24 00
No. 18 cotton parallel.................................	25 00
No. 16 cotton parallel	32 00
No. 18 cotton reinforced heavy	35 00
No. 16 cotton reinforced heavy..............................	42 00
No. 18 cotton reinforced light.......................... ...	30 00
No. 16 cotton reinforced light . .	36 00
No. 18 cotton Canvasite cord................................	29 00
No. 16 cotton Canvasite cord................................	35 00

FUSES, ENCLOSED—

250-Volt	Std. Pkg	List
3-amp. to 30-amp..............................	100	$0 25
35-amp to 60-amp	100	.35
65-amp to 100-amp	50	90
10-amp. to 200-amp.....	25	2 00
25-amp. to 400-amp...	25	3 60
2-amp. to 600-amp.	10	5 50

600 Volt	Std Pkg	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	60
65-amp. to 100-amp.	50	1 50
110-amp. to 200-amp. ...	25	2 50
225-amp. to 400-amp. ...	25	5 50
450 amp. to 600 amp. ...	10	8 00
Discount Less 1-5th standard package	30%	
1-5th to standard package	40%	
Standard package .	50%	

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package . .	$4 75 C
0–30 ampere, less than standard package .	6 00 C

LAMPS—Below are prices of quantities in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B Watts	Plain	Frosted	No. in Package	Mazda C Watts	Clear	Frosted	No. in Package
10	$0 35	$0 38	100	75	$0 70	$0 75	50
15	.35	.38	100	100	1 10	1 15	24
25	35	.38	100	150	1 65	1 70	24
40	.35	.38	100	200	2.20	2 27	24
50	.35	.38	100	300	3 25	3 35	24
60	.40	.45	100	400	4 30	4.45	12
100	.85	.92	24	500	4 70	4 85	12
				750	6 50	6 75	8
				1000	7 50	7 75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $1,000 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

		Each
Hubbell, porcelain No. 5406,	standard package 250	$0 24
Hubbell composition No. 5467,	standard package 50 .	32
Benjamin swivel No. 903,	standard package 250 .	.20
Hubbell current taps No. 5638,	standard package 50.	40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York

No	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	... $12 00	$14 00	$13 90	$25 00
12	.. 13 25	15 70	18 05	30 70
10	... 18 30	21 00	23 85	41 50
8	.. 25 54	28 60	32 70	56 77
6			51 40	
4			70 00	
2	..	....	101 80	...
1	....	.....	131 86	.
0	... .	......	160.00	...
00	... .	.....	193 50	..
000	.. ..	.....	235 20	
0000	... ..	.....	288 60	

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$11 00	$14 50	$30 40	$16 00	$21 00	$33 00	$9 92	$15.25	$27.75
10	19 20	25 70	49 00	27 20	31 00	69 00	20 25	24.25	46.90
8	26 95	34 25	67 00	38 00	42 00	78 00	27 60	32.60	
6	43 90	46 20			65 00	130 00	48 25	54.75	
4	62 35	65 15	...		93 00		66 90	73.75	...
2	92 60	96 25	....		140 00		96.00	104.50	.
1	120 95	125 20	.....	...	182 00		121.00	136 40	
0	164 80	164 80	.....	...	242 00	...	169.00	174.60	.....
00	.	203 35	.....	...	290 00	...	203.50	214.00	.....
000		248 40	. ..	. .	360 00		246.00	257 50	.
0000	..	302 55	...		435 00		295.50	308.50	...

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap.			¾ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0 33	$0 30	$0.60	$0.39	$0.36	$0 66

Less 1-5th standard package	+20%
1-5th to standard package ...	+10%
Standard package .	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)............................	36c. lb.
No. 18 B.&S. regular 1-lb. coils........................ ...	37c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots...................	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots...................	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots.................... ...	46c. lb.
Soldering paste, 2 oz. cans Nokorode..............................	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0 42	$0 68	$1.02	$1.36
60	74	1.22	1.84	2 44
100	1 50	2 50	3.76	5 00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

Size, Amp	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	.70	1 06	1.60	2 120
60	1 18	1.80	2.70	3.60
100	2 38	3.66	5.50	7.3
200	4.40	6.76	10 14	13.50

Discounts:

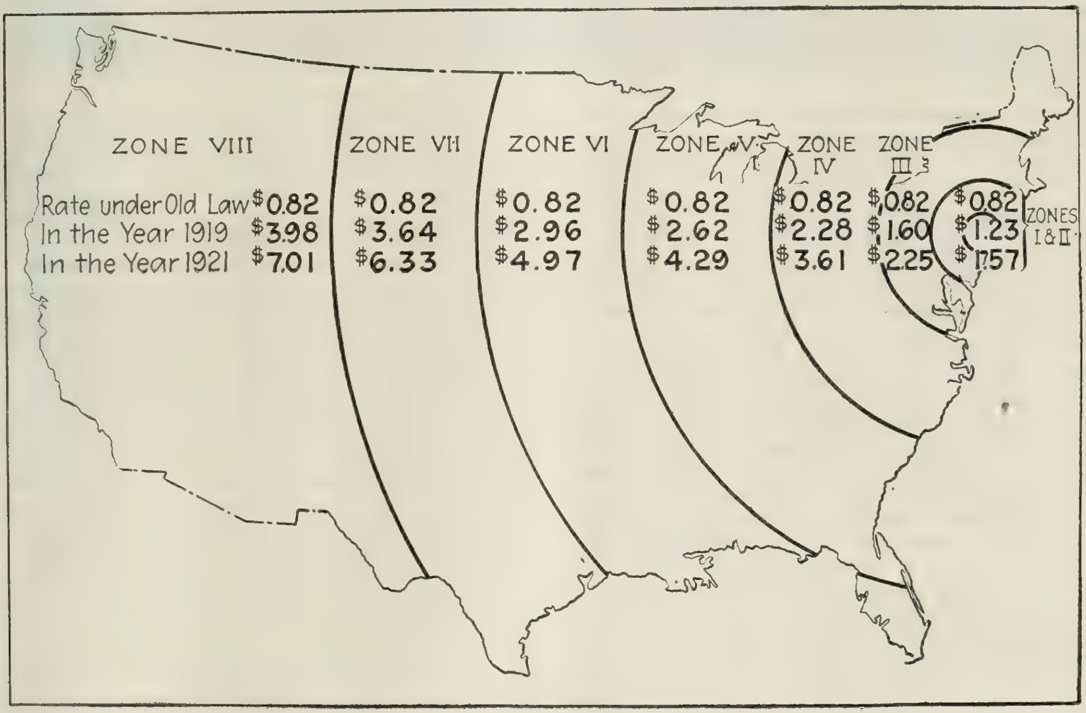
Less than $10.00 list value...........................	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value....................	—15%
$50 to $200 list value...........	—20%
$200 list value or over..............................	—25%

POWER

Volume 49 New York, June 10, 1919 Number 23

Where Do You Live?

This Map shows the zones created by the Postal Zone Law and the postage to be paid on your copy of Power.



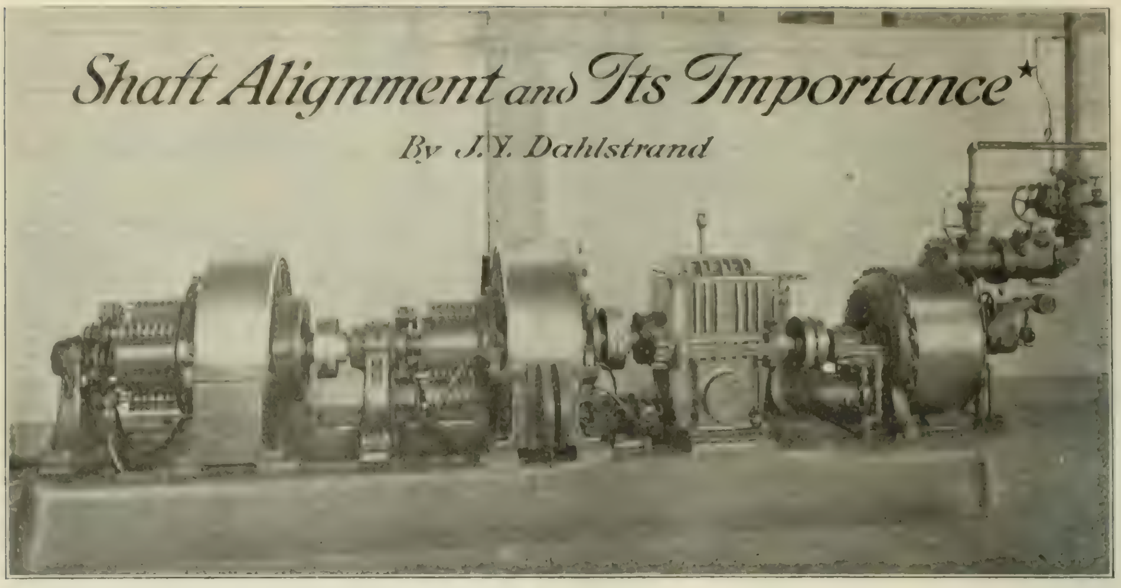
NOTE—For the year 1918 we paid the penalty postage. For the year 1919 we are billing our subscribers who live west of the Mississippi $1 extra to cover a part of the Zone Postage. There will be another increase in postage in 1920 and still another in 1921. (See Map.) If the Zone law is not repealed, we shall be compelled to readjust our subscription price so that the Subscriber will pay according to the Zone in which he lives.

Prior to this Zone Law all citizens had equal rights.
Why should not these rights be restored?

Ask your Congressman!

Shaft Alignment and Its Importance*

By J. Y. Dahlstrand



Reasons are presented as to why two or more members of a unit mounted on the same bedplate lose their alignment. This can occur during the shop test or when the unit is placed in position in the plant. Uneven strain on the anchor bolts, incorrect foundation, improper and insecure doweling and wearing are causes for misalignment.

IF IN THE operation of small and medium-sized rotating machinery—pumps, generators, motors, blowers or turbines—the various difficulties that come up such as trouble with bearings, shafts and packings, were recorded and traced to their origin, it is likely that 60 per cent. of them would be found to be the direct or indirect result of bad shaft alignment. The question of alignment is so old and appears so simple of solution to the average power-plant engineer, that in the majority of cases he ascribes other conditions as causes of the difficulties encountered.

In spite of all that has been said and written on this subject, the alignment of rotating machinery in the average power plant is far from what it should be to insure long life and trouble-proof operation, which condition, after all, in the majority of cases can be obtained with small effort and retained at low expense.

The results under given inferior conditions of alignment do not vary greatly, except that they become more complex and far-reaching the longer such conditions exist. These results are vibration, burned-out bearings, bent shafts, crystallization of material in the revolving elements, resulting in breakage of shafts, couplings and other rotating parts—and this often where the stresses in these parts appear practically negligible.

It should be noted that under such conditions of shaft alignment some kinds of machinery do not exhibit the results with the same rapidity as others. As a general rule machines operating at lower speeds—below 2000 r.p.m.—stand up in service longer under the foregoing conditions than do higher-speed machines. From this, as well as some other causes, has come the conception that machinery having operating speeds of 4000 r.p.m. and up is more unsatisfactory than machinery operating at speeds lower than 4000 r.p.m., a conception that undoubtedly has good foundation if considered from certain standpoints. As the result of the higher stresses and surface speeds high-speed machines require correct static and dynamic balance, correct alignment and the best of lubrication. In many cases the cost of providing these conditions more than offsets the actual gain in economy and first cost of the high-speed machine.

Assuming that the foregoing statements concerning conditions as to alignment of units in the average power plant are in accordance with the facts, let us investigate the causes and reasons for the existence of these conditions. In the writer's opinion there are two popular misconceptions which are more responsible than anything else and are as follows:

The couplings generally used to transmit the power from the driving member of the unit to the driven have been termed flexible couplings. This name is correct in so far as it refers to movement in axial direction, but is not to be construed to mean that this type of coupling will permit of any appreciable error in alignment. Contrary to common supposition, no coupling has yet been devised, as far as I know—and is not likely to be—which will compensate for any such error.

When two or more members of a unit are mounted on a common baseplate, lined up correctly in the manufacturer's plant and then removed to be installed in the customer's plant, it is common that too much reliance is placed on the baseplate to keep the unit in line. This is wrong. A baseplate, even if it is high and massive, is a flexible object. It is unsafe to rely on any baseplate alone to keep a unit in line.

If all the members of the unit are mounted on a common baseplate when leaving the manufacturer's plant, it is safe to say that while in test the unit was in line. However, there is no certainty that the baseplate was not sprung at the time of testing. It does not require a very great force to spring a baseplate of a reasonable section out of shape. Furthermore, it is almost impossible to avoid this, which is clear when it is considered that the baseplate is ordinarily bolted down by using fairly good-sized bolts, and the workman does not have to apply a very great force on his wrench to bring about a force in the direction of the bolt which is considerable. A unit mounted on a baseplate such as this, whether actually sprung in test or not, when finally placed on its foundation will have to have its baseplate brought back into the condition that it had while testing in order to be in line. If this is not done, a change in the doweling between the baseplate and the various members mounted upon it must be made.

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It is not uncommon to find that a customer receives a unit—say a turbine and a generator of small capacity, 10 to 50 kw., mounted on a small baseplate—and will place this set on a common floor or some other foundation that appears to be reasonably smooth, tighten it with holding-down bolts and expect the unit to be in line. It is purely accidental if the machine is actually in line. It is not uncommon that the alignment varies as much as $\frac{1}{16}$ in., even with relatively heavy bases under them, and mounted on apparently smooth foundations.

Units may have been erected and lined up perfectly, but may have developed misalignment. One common cause of this is that the foundation is not made correctly. Foundations under units should be sufficiently rigid to maintain the alignment of the unit. Solid concrete foundations are preferred to the hollow construction, as the latter have a tendency to furnish sounding boards where vibrations are set up and intensified. Also the rigidity of a solid foundation is generally better. Concrete foundations ought never to be tied to the foundations of a building. For certain units steel foundations are satisfactory, provided they are made with the rigidity particularly in view. No unit, even if small in size, should be placed directly on a wooden floor, unless this floor is very heavy and has been installed long enough to be thoroughly seasoned. Only small units should be placed in this manner.

It is always more satisfactory to set the unit on a slab of concrete, from 8 to 10 in. thick, poured directly on the floor and reinforced with steel rods or expanded metal embedded in the concrete 1½ in. above the bottom surface and the same distance below the top surface of the slab.

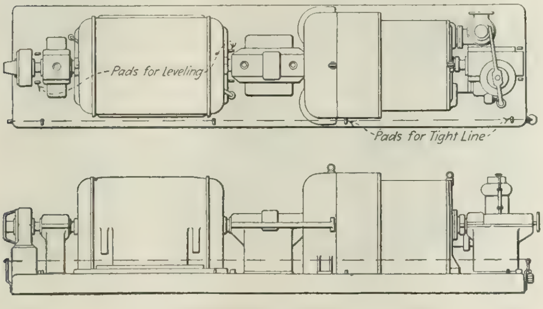


FIG. 1. TURBO-GENERATOR UNIT ON COMMON BASEPLATE.

After a unit has been placed on its foundation in proper alignment, using steel wedges inserted at various points under the baseplate and anchoring the baseplate to the foundation by means of holding-down bolts, the baseplate should be grouted to the foundation to provide bearing along its entire lower surface.

In some cases units are shipped out with the various members mounted on different baseplates, to be set on the same foundation. This is found to be satisfactory, but will require a certain amount of additional work in erecting.

Improper and insecure doweling of the members of the unit to the baseplate is another cause for change in alignment after the unit has been erected. Still another is wear of bearings. Foremost among other causes tending to change alignment are pipes or stays attached to the unit without proper supports. Steam and exhaust lines on steam turbines are particularly referred to. These pipes must be supported and provided with expansion joints so as to relieve the turbine of strains due to weight, expansion or unbalanced pressure. If this is not done, the casing of the turbine may be so distorted as to cause serious misalignment.

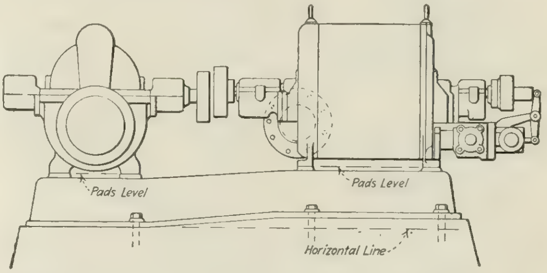


FIG. 2. EXAGGERATED CASE OF SPRUNG BASEPLATE

Some manufacturers have adopted a method to secure proper alignment in the field when erecting, with a minimum amount of difficulty, as follows:

Fig. 1 illustrates a steam turbine coupled to an alternating-current generator and mounted on a common baseplate. This unit is to be tested at the factory, after which it is shipped out to be installed in the customer's plant. It is desired that the same conditions of alignment that the unit had in test be reproduced. If the individual parts, the pedestals and frames, are doweled to the base in the proper manner, the alignment sideways will be taken care of if the unit is placed in the same position of level (to be checked at various points) as it had in the factory, in a direction at right angles to the center line of the unit. However, as baseplates, no matter what thickness, are always in some degree flexible, the original alignment in the vertical plane cannot be reproduced so readily. It is never safe to use levels to prove this alignment as the baseplate may be sprung, as indicated in an exaggerated manner in Fig. 2.

To facilitate the alignment in the vertical plane, there are provided on top of the baseplate certain leveling spots, or measuring points, which are filed and scraped at the time the unit is being tested, with all parts mounted on the baseplate and in alignment. The procedure is as follows:

The base should be placed in position, with all its pads in as good level as possible, using an ordinary 8- or 12-in. level. The reason for the expression "in as good level as possible" is as follows: It is never possible to plane a baseplate so that the surface of its pads will be absolutely parallel, because a baseplate is flexible and when bolted to the planer it will always be sprung one way or the other. To the layman this statement sounds strange, but it is nevertheless a fact. The amount the pads will be out of parallel varies, of course, with the size and length of the baseplate as well as with its rigidity, but it is not uncommon even with the best of men doing the work to have the pads nonparallel a considerable amount after the baseplate is removed from the plane of the table. The expression as used is supposed to denote that the baseplate should be so placed that the angle the pads at the two ends of the baseplate are inclined toward each other will be approximately divided in two by a horizontal line. All parts, pedestals and frames should then be assembled on the base and the coupling lined up accordingly. Later, certain methods used in aligning shafts will be illustrated.

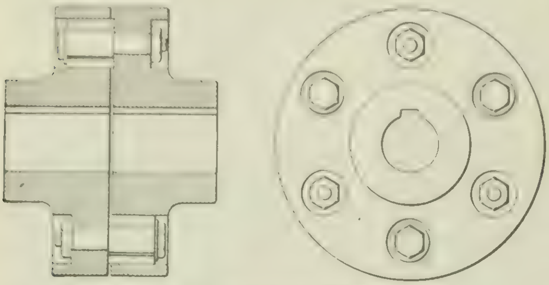


FIG. 3. PIN-TYPE COUPLING

A tight line of about 0.017-in. piano wire should be strung along one side of the base, extending if possible the length of the unit, directly over a number of ½ x 1-in. pads (purposely made small to allow easy filing and scraping) on the base provided for measuring purposes, one of these pads near each end of the wire and others between. The wire should be held tight with a 30-lb. weight at one end. The distances to the small pads from the wire should then be measured, and the spots under the wire to which the measuring was made should be stamped with an *O*, the measuring in the field to be done to the center of this *O*, and the distance to the wire should be stamped alongside this same *O*, in thousandths of an inch.

For obvious reasons it is desirable to keep the distance to the wire an even number of inches, and if the base has the same height throughout it is desirable to keep the distance to the wire exactly the same on account of the sag in the wire as well as minor inequalities in the planing of the pads. This will invariably mean that some of the pads will have to be filed or scraped down a few thousands of an inch. Even though the distance to the wire is an even number of inches, the figures should be stamped in decimals to indicate that the distance is correct within a thousandth of an inch.

The leveling across the baseplate may be done both in the shop and in the field with an ordinary 12-in. level. Separate pads, 1½ x 1 in., are provided on the base for this purpose. These pads should be filed or scraped down until they are in level when erecting in the shop.

All the foregoing is to be done during the test of the machine, while the various parts are mounted on the baseplate and are in alignment.

Incidentally, it might be well to warn against checking the level of the pads with an ordinary instrument without turning this end for end, as the glass is not always parallel with the bottom surface of the level. Also, it is never safe to check from one end of the bubble only. The reason for this is that the expansion of the liquid changes the size of the bubble. If the level was determined by noting which division one end of the bubble reached, it might easily be possible to make an error of several thousandths of an inch in a 12-in. length.

Later, this unit is shipped to the customer's plant, sometimes taken down, sometimes shipped in the condition in which it was tested. In either case, when put on the foundation in the customer's plant, a similar tight wire should be strung across the pads in an axial direction, using an equal weight, and the same dimensions reproduced as were obtained in the factory by putting wedges under the baseplate. Also the alignment across the baseplate should be checked in a similar manner. It is unnecessary to say that the machine should also be placed as nearly level as possible in an axial direction. This, however, is not as important as it is that it be placed correctly in line; in fact, certain builders of the Parson type of turbine incline their shafts a considerable amount for certain reasons in connection with the functions of the balance pistons on the turbines.

The couplings between the members of the unit—in order to be successful in operation—should allow free end movement of the two shafts without imposing undue strains or stresses on any of its parts or creating any end thrust on the ends of the shafts. They should have no loose parts and should be as free from wear and lost motion as possible. If not inclosed in housings, they should have no projecting parts to cause undue windage and noise, and which would be unsafe because of the possibility of catching in workmen's clothing.

Two types of couplings are commonly used. The pin type in its most common form is illustrated in Fig. 3. It consists of two semi-steel or forged steel flanges, in which are inserted steel pins secured with nuts, washers and cotters in one coupling half and carrying on the opposite end rubber bushings, brass-lined on the inside and with outside bearing on the inner face of the bored-out holes in the other coupling half. The holes for the pins are bored out accurately with each other and so as to be parallel with the bore through which the shaft passes.

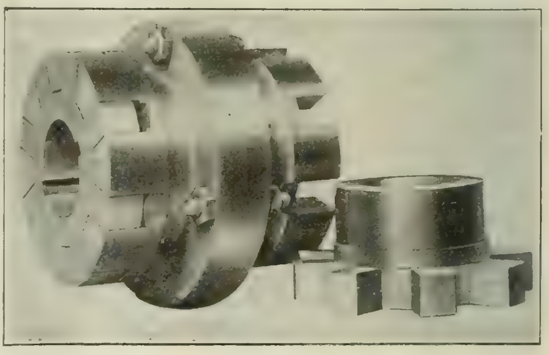
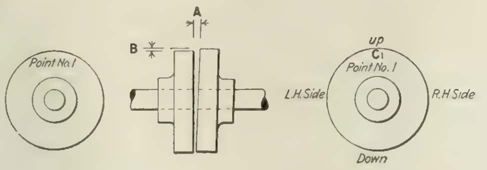


FIG. 4. CLAW-TYPE COUPLING

There are various other constructions of this type of coupling. Sometimes the rubber bushings are substituted with bronze bushings and lubrication is provided for the bushings and steel pins. In such cases it is naturally necessary to inclose the coupling. This latter type will allow for even a smaller variation in shaft alignment than will the rubber-bushing type.

Either one will not operate successfully unless the shaft alignment is within seven or eight thousandths of an inch.

In the claw type of coupling, Fig. 4, each half consists of two parts: The inner one, or sleeve, keyed to the shaft and provided on the outer flange with claws; and the outer one, which has two flanges and is provided with a set of claws in one of these flanges. These fit into the spaces between the claws on the fixed sleeve.



Important Note:
The two Shafts must always be turned over together while measuring so that point No. 1 on each of the Couplings always are Opposite each other

STANDARD TABLE OF DIMENSIONS TO BE OBTAINED EACH TIME ALIGNMENT BETWEEN TWO SHAFTS IS CHECKED

Distance "A" at Point No. 1 for Both Shafts turned Over Together to Varying Positions		Distance "B" at Point No. 1 for Both Shafts Turned Over Together to Varying Positions	
UP	0.124	UP	0.008
R. H. SIDE	0.124	R. H. SIDE	0.008
DOWN	0.124	DOWN	0.008
L. H. SIDE	0.124	L. H. SIDE	0.008

The Above Indicates that Shafts are Parallel and in Line.
If Dimensions not Constant for Each Position they Should be made so by Shifting or Shimming Under Feet of One of the Numbers

FIG. 5. DATA FOR ALIGNING COUPLINGS

The two shafts are connected to each other by bolting the outer sleeves by means of the plain flanges. This type of coupling should preferably be lubricated, as otherwise wear is liable to take place. Even though from this construction one might suppose that it would be capable of taking care of considerable misalignment, this is not correct. This coupling will not operate satisfactorily unless the alignment comes inside the figures mentioned for the first type of coupling. The claw type of coupling must be inclosed. It is used in preference to the pin type to transmit higher horsepowers and to save space and weight.

The methods used for checking the alignment of the shafts, whether the one type of coupling is used or the other, are numerous. Perhaps the most accurate is the one where a steel line is used. In order to check the alignment of the unit using a steel line, it is necessary to remove the upper half and rotor of the unit. The lower half of the bearings, however, will be left in place. The steel wire is then stretched from one outer bearing to the other, exactly in the center of the bearings, due allowance having been made for the fact that the journal has a certain clearance in the bearing. The alignment of the intermediate points is prefected in accordance with this wire after corrections have been made for the sag in the wire, which will vary, according to the size of the wire, the span and the weight stretching it. This sag may be calculated from the following formula:

$$D = \frac{WL^2}{8X}$$

Where
W = Weight in pounds per inch diameter of wire; L = length of span in inches; D = deflection in inches; X = weight in pounds of weight applied.

Another method, which is more common because more convenient, is that of checking the alignment by the coupling faces and diameters. This does not require any dismantling of the unit, but simply the removal of any guard that may be present outside the coupling. It can be done by anyone who is in possession of a set of "feelers," or thickness gages, and an ordinary steel scale. The approximate procedure to be carried out is as follows:

Two shafts may suffer from two kinds of misalignment. They may be out of line sideways (in other words, the ends of their axes may not meet) or they may be nonparallel. It is always possible to check the alignment of two shafts from the two coupling halves even though these halves do not have their faces perpendicular to the axes nor their outside circumference concentric with the shafts.

There are two requirements to be fulfilled in order that the shafts should be in line. The first one is that the distance A, Fig. 5, between the coupling halves should be the same whether this point is up, on the right-hand side, down or on the left-hand side, when the two shafts are turned at the same time when measuring this dimension. A convenient way of doing this for the pin-type coupling, is to insert the coupling pin, without bushing, through both halves of the coupling and leave this in while measuring. It is necessary that the two shafts, while taking this measurement, be pushed as far apart as the thrust bearings will allow them to go, in order to avoid errors in measurements due to end movement of the shafts.

In the second place it is necessary that the dimension B at the point 1, as indicated in Fig. 5, should be the same no matter whether this point is up, on the right-hand side, down or on the left-hand side. It is important to remember that when taking this measurement both shafts should be revolved together.

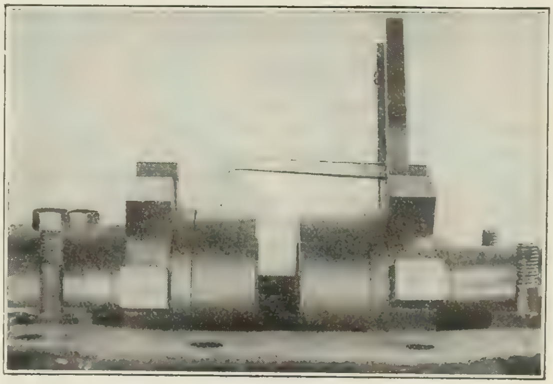


FIG. 6. METHOD OF CHECKING ALIGNMENT

The table in Fig. 5 shows all the dimensions which it is necessary to find on the coupling in order to determine the alignment both as far as being parallel and and as far as both axes meeting each other are concerned. A table of this kind should be made up each time it is desired that the alignment of a machine be checked.

In literature and instruction books on the subject of alignment one will always find that customers and engineers are asked to try to bring the faces of the two couplings parallel to each other. This is not entirely safe, as in some cases, while the coupling bolts will be parallel to the bore of the coupling half, the faces are not necessarily perpendicular to the shaft. If the amount which they are out is small, this fact is not necessarily an indication of poor workmanship and will make no difference in the operation of the machine. However, they should naturally come as close to being perpendicular as possible.

The foregoing method, however, avoids errors due to incorrect machine work. The alignment of the shafts may be checked no matter what the condition of the couplings may be. For this reason the writer considers the foregoing method more satisfactory.

It is highly desirable that the alignment of all units, whether small or large, in power plants be checked at certain intervals to see that the machinery is kept in line, and it is recommended that the method just outlined for the pin-type coupling be used in doing this as it is a quicker and more convenient method, in the majority of cases requiring only four or five minutes, and may save great inconvenience and expense.

The method generally used for checking the alignment when the claw-type coupling is used is approximately the same. Fig. 6 shows this type of coupling with a test rod inserted. The distance between the sleeve and the end of this rod is checked with a thickness gage in the same manner as the distance *B*, Fig. 5, was checked in the pin-type coupling. In all cases the two shafts should be rotated together. The distance between two claws directly opposite each other should be measured in the same manner as distance *A*, Fig. 5, was measured. In order that the shafts should be in line, these two distances should be the same no matter whether the points measured are up, on the right-hand side, down or on the left-hand side.

Heating as an Equalizer in Central Stations

In 1911 and 1912 M. A. Beaurrienne presented to the Société des Ingénieurs Civils two studies, one on city heating from central stations and the other on combinations which permit the simultaneous production of electric energy and heat.

The variations in consumption of steam in a station are an obstacle to its economic reproduction. In order to regulate this consumption, the heat produced between the peaks of consumption may be accumulated in reservoirs of hot water, this heat to be utilized afterward in industrial processes, lavatories, washing and heating.

These reservoirs are fed through automatic valves which open when the steam pressure in the system goes above a predetermined point, and their efficiency, when well insulated, is superior to 95 per cent., even when the mass of water is left without giving up or receiving heat during twelve hours.

If a station should have a maximum production of ten tons, for example, six generating units would be installed, so that they could each produce two tons. Five of these units would be sufficient to assure the total production, and the sixth would serve for the recharge. One would put into service a greater or less number, so that each would function always under the conditions corresponding to its most economical service.

Using automatic stokers, the thickness of the fire bed, the rate of feeding, etc., can be regulated for the entire period, and the boilers run at a uniform rate, which will conduce to a better efficiency. The necessary attention of the fireman, not always the most economical, will also be reduced.

Monsieur Beaurrienne then considers the transportation of the heat by different means, air, hot water and steam at high or low pressure, and shows that in most cases the transportation by hot water is the most simple and economical.

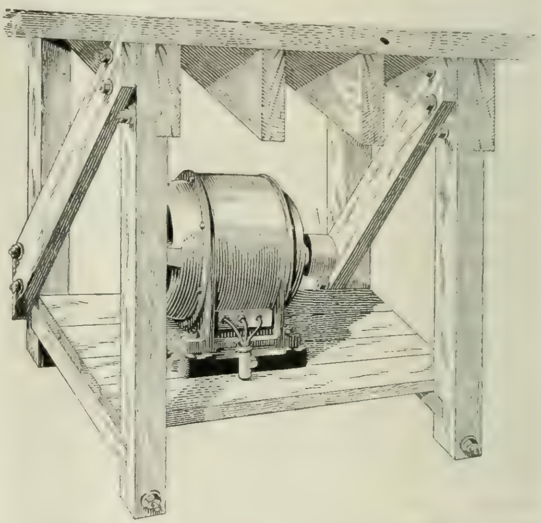
For the heating of industrial buildings and workrooms of considerable height, the circulation of heated air is preferable to the employment of suspended pipes. If the fans or blowers by which the air is circulated are run by engines the exhaust of which can be absorbed by the heat accumulated, the fuel consumption for such purpose will be negligible.

Monsieur Beaurrienne considers the general distribution of heat in a city, steam for industrial usages being furnished by the boilers of the central station, and that for heating by the exhaust steam of the central stations' prime movers. This combination not only would permit the reduction of the weight of steam used, but would result in a better performance of the boilers under a uniform load.

Overhead Wooden Platform for Motors*

By L. M. Harrison

When floor space is at a premium, it may be desirable to mount electric motors on platforms suspended from ceilings instead of supporting them on the floor. In the illustration are shown the details of a satisfactory support for motors of capacities up to 30 hp. Four 4- x 6-in. timbers bolted to the floor joists sustain the platform floor. To these vertical pieces are clamped two 3- x 4-in. cross-timbers which act as beams to which the 2-in. tongue-and-groove flooring is spiked. Two 1-in. tie-rods bind together the lower ends of the vertical supports. Where the side pull is great, to insure against shifting, diagonal braces, as shown, may be used to prevent lateral displacement.



STRUCTURAL DETAILS OF MOTOR PLATFORM

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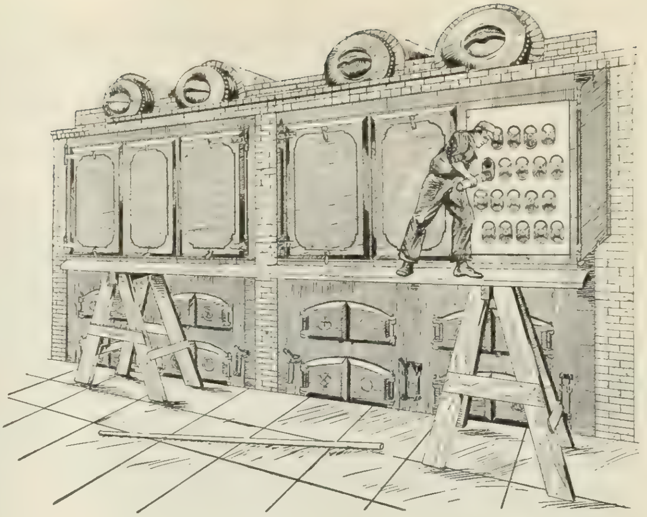
Boiler-Tube Failures

BY WALDO WEAVER



ONE may well wonder why there are so many boiler-tube failures when so much is being said and done toward economy and the "safety first" movement. A few years ago it was a common thing to go into a plant and be told that some of the boilers had not been turbined for a matter of nine months or a year. On one occasion I was amused when a fireman said to me, "We call these two boilers on this side the summer boilers and those on that side the winter boilers." They ran two boilers during the summer and cleaned the other two ready for winter; then during the winter they cleaned the other two boilers and got them ready for the next summer.

Most of the tube failures in horizontal water-tube boilers are caused by the accumulation of sludge and scale, which may be very thin and light, in the two bottom rows of tubes directly over the fire. This sludge is held in suspension while the boiler is steaming rapidly, but when the fire is deadened it will invariably stop in mass and accumulate in little piles in the bottom tubes, generally toward the first baffle in vertically baffled boilers. Naturally, this will cause the tubes to burn when the fire is brought up quickly. It has been thoroughly demonstrated that running a boiler to 275 per cent. capacity will not burn the tubes if they are clean, free from oil and the baffling and arches are correct.

There is one way to prevent the loss of tubes in a horizontal water-tube boiler, and that is to turbine the two bottom rows every time the water is changed. Another valuable thing to remember is—Do not use a feed-water treatment that will cause the scale to break loose, thus giving it an opportunity to circulate with the water and eventually to accumulate in the bottom rows of the tubes and burn them.

Some years ago I told what good results had been achieved through the use of graphite as a scale remover. However, I afterward discovered that I was losing a lot of tubes because the graphite would loosen the scale in the drums and headers and it would then lodge in the bottom rows, as previously explained. Substituting a feed-water treatment compounded to suit the water and having a caustic base practically eliminated this loss of tubes.

I had a similar experience in another plant after using a noncaustic boiler compound which, it was claimed, would put a coating on the tubes, etc., making it impossible for scale to adhere to the surfaces. The loss of tubes in this case was enormous, running as high as 9 to 11 tubes per month per boiler, whereas before using the "dope" we seldom lost more than one tube per boiler in six weeks. Needless to say, I quickly discontinued the use of this stuff and had the water analyzed and purchased a treatment having a caustic basis. After doing this, our tube loss returned to normal and eventually we forgot we had any tubes in our boilers.

River and canal water will usually cause a great loss of tubes due to the presence of sewage, mud and chemicals from manufacturing plants. I have found this to be true in three plants in different parts of the United States. Changing to well or spring water stopped the trouble in all three cases notwithstanding the river water was lower in solids than the well water.

Engineers do not attach enough importance to oil in the feed water as condensate. Some years ago I witnessed a sad experience with a small boiler; tubes were lost every week, also some headers. Frequently, the boilermakers would not get back to the shop before they would be recalled. It seemed like a mystery to me then, but after I learned that they had been using the condensate from the surface condenser, which was milky, and as I knew they had always used a noncaustic compound, it was easy to understand the cause of the trouble. After they discontinued the use of the milky condensate, they had no difficulty.

I have witnessed some very distressing tube trouble due to an excess of soda ash in the feed water where softening plants are installed. My theory is that such an excess causes the water in the tubes to foam and prime out of the tube or away from the side exposed to the fire, with the result that the tube is burned. Tubes are not burned even when running the boiler at 300 per cent. rating where natural water is used.

Many tubes are lost because of the blowpipe action of the flames and gases. This is well known among designers of high-grade boilers, but we never hear anything about it from operating engineers. This results from the arch being too close to the tubes and also from restricted area or volume in the first pass. Baffles located behind the first or front row of tubes in some types of boilers will cause a great loss of tubes.

The absence of baffles on top of the first pass adjoining the vertical baffle will produce a blowpipe action which will cause bagged tubes near the baffle. Leaky baffles will also cause a blowpipe action. Extreme air pressure, say 4 to 5 in., on underfeed stokers often causes tube trouble where the fires are not given proper attention. Boilers should not be driven in excess of 150 per cent. rating where bad water must be used. This should be adhered to as a "safety first" measure. Nothing can be gained by snap judgment; it is a matter of careful analysis and good judgment to prevent the loss of tubes in water-tube boilers.

The Construction of 120- and 240-Volt Electromagnets and Solenoids

By Henry W. Townsend

Data are given for the construction of a number of 120- and 240-volt electromagnets and solenoids. The theory of the design is not gone into—the data given being sufficient to show what may be expected of the magnet after it is built.

IN A PREVIOUS article data were given on the design of electromagnets and solenoids to operate on battery circuits up to 15 volts. Going beyond this voltage, in general, means about 120 or 240 volts for lighting and power circuit, and it is on these voltages that the practical electrician and power-plant operating engineer frequently has the problem of building solenoids or electromagnets; therefore the designs in this article are chosen to meet some of these conditions.

Fig. 1 gives the working dimensions of a small 120-volt direct-current double-pole lifting magnet that has a lifting capacity of 28.5 lb. when using a current of 0.1 ampere. Each coil is wound with approximately 1.65 lb. No. 30 B. & S. gage enameled wire and has a resistance of 550 ohms; total resistance, 1100 ohms.

Wind the coils as evenly as possible, placing a layer of thin paper on every three layers to keep the winding even and smooth. All iron parts are of soft wrought-iron stock. The bobbins are formed by mounting fiber disks on each end of the core, as indicated in the figure. Three layers of paper, well shellacked, are wound around each core before winding on the wire. Drill slanting holes through the fiber ends of the bobbins for bringing out the flexible leads. It is always best to wind a layer of cord or thin fiber over the outside of the coils to protect them against mechanical injury.

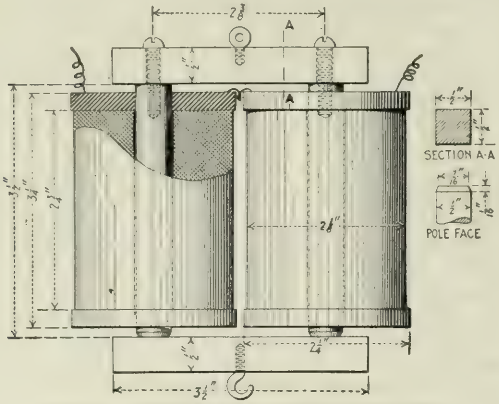


FIG. 1. DOUBLE-POLE ELECTROMAGNET

Connect the two coils in series to give resultant north and south poles. The pole faces are chamfered off as shown in the figure to increase the flux density at contact with the armature. This electromagnet is suitable for constant duty, the coils being designed so that the conductors have about 1000-circ.mil cross-section per ampere. This has been found good practice and need not be exceeded except in very large magnet windings of over two or three inches in depth, where the heat is dissipated with difficulty. For intermittent duty, wire of about 570- to 800-circ.mil cross-sectional area per ampere is suitable.

The principal dimensions of a 120-volt direct-current single-pole solenoid are shown in Fig. 2. The manner of mounting the solenoid on two brass straps secured to the wrought-iron yoke is indicated at *B*. The core may be made of mild cold-rolled steel. The coils of all solenoids must have a brass tube for the core to slide in. The bobbin is made by placing a layer of thin fiber around the brass tube and pressing the fiber end disks over the fiber layer and gluing them in place, as this will allow removing the tube after the coil is wound, so that the solenoid may be assembled. The coil is wound in even layers with 3 lb. of No. 28 B. & S. gage enameled wire, giving it a resistance of approximately 366 ohms. The current taken on 120-volts is 0.3 ampere direct, which gives about 3342 ampere-turns. The pull in pounds at different strokes are as follows: At ¾-in. stroke 2.5 lb.; ⅞-in., 2.25 lb.; 1¼-in. 1.8 lb.; 1⅝-in., 1.4 lb.; and at 2-in., 1 lb.

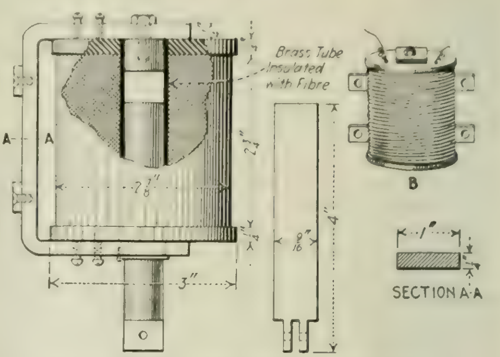


FIG. 2. SMALL SINGLE-POLE SOLENOID

The design for a medium-sized 120-volt direct-current single-pole iron-clad solenoid is given in Fig. 3. The iron yoke is formed and placed around the coil bobbin after it is wound. The opening in the yoke is joined by a wrought-iron lap plate, with four machine screws tapped into the yoke as shown. The yoke is of soft wrought iron and the core may be of the same stock or mild cold-rolled steel. Do not make the core too tight a fit in the brass tube; $\frac{1}{64}$-in. or $\frac{1}{32}$-in. clearance between the core and tube is generally allowed on small direct-current solenoids. The bobbin is wound with approximately 3 lb. 3 oz. of No. 27 B. & S. gage single-cotton-covered magnet wire, giving a resistance of about 238 ohms and taking a current at 120 volts, of 0.5 ampere. With the core all the way in, a total maximum pull of 20.5 lb. was developed on test. At a stroke of 1-in. the pull was 6 lb.; at 2-in., 3.5 lb.; at 2½ in., 2.5 lb.

Fig. 4 shows the design features of a large-sized 240-volt direct-current iron-clad single-pole solenoid having a pull at 1-in. stroke of 20 lb. The magnet spool is wound with approximately 8 lb. of No. 26 B. & S. gage enameled magnet wire, and the bobbin is made as described for Fig. 2. The resistance of the coil is 419 ohms, and the current on 240 volts is approximately 0.5 ampere. For 120 volts wind the coil with the same quantity of magnet wire three sizes larger, or No. 23. The various pulls in pounds at different strokes were not tested, but can be readily judged by the relative pulls obtained with the other solenoids.

The curves, Fig. 5, give the general characteristics of both the simple and iron-clad solenoids. Curve *A* shows the pull for various strokes of the core for a simple solenoid. Curve *B* indicates the pull obtained from the same coil when provided with an iron return magnetic circuit or yoke. The difference between the two is much more noticeable at higher degrees of magnetization. Note the pull developed by the iron-clad type of solenoid near the end of the stroke, as well as the uniform pull for considerable distance at the center of the coil. The yoke is left solid at the top end, a hole being drilled through it at the bottom only, to permit the iron core to enter the solenoid. The efficient pull for iron-clads solenoids extends for about 0.6 of its length, measuring from the inside face *X* of the yoke at the top, as indicated in Fig. 5.

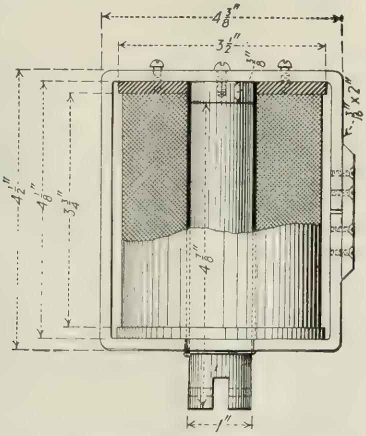


FIG. 3. MEDIUM-SIZE, SINGLE-POLE SOLENOID

When an electromagnet or solenoid is built make a careful electric and magnetic lift test. The data thus obtained will prove valuable for further reference. Take pull readings every inch or half inch for solenoids and construct pull curves for various actions like those shown in Fig. 5.

Fig. 6 shows the working dimensions for building a magnetizing electromagnet that can be used for tractive or lifting purposes, etc. Any form of poleshoes may be forged out of wrought-iron stock to suit the kind of work in hand. The poleshoes shown are used for magnetizing small permanent steel magnets, such as telephone receiver magnets. Similar poleshoes, but designed with wider faces, carefully filed or machined off, can be used for magnetizing small magneto field magnets. In magnetizing such magnets, it has been found by experience that opening and closing the circuit several times per minute gives best results, made while the magnet is held in contact with the poleshoes. Some concerns employ a special automatic relay arrangement for the purpose, which opens and closes, or shunts the magnet coil circuit rapidly, at the rate of two to four seconds per interruption.

Usually, a permanent magnet will be fully magnetized after one to three minutes. The steel for the magnet should be heated a cherry red and plunged into water, making it glass hard. The harder it is the greater its retention of magnetism. Knocks and jars tend to weaken permanent magnets. They are sometimes "aged" artificially where great constancy is essential, as in electrical instruments, by placing them in boiling water, by lightly rapping with a vibrating device, such as an electric-bell movement, or by a mechanical rapper.

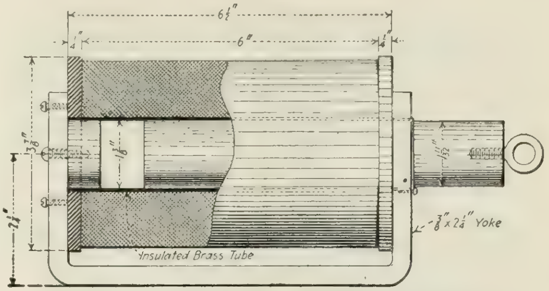


FIG. 4. LARGE-SIZE, SINGLE-POLE SOLENOID

The spools for the coils are made by placing on the iron cores ⅛-in. fiber disks drilled or bored out to fit tightly on the core ends. The cores are then covered with three layers of oiled linen or heavy paper, well shellacked. Be sure the oiled linen comes up tight against the fiber disks to prevent the possibility of a "ground" due to wire touching the iron core.

The magnet as originally built, to stand up under all-day service, was calculated to allow about 1400 circ.mil per ampere for the magnet-wire cross-section. Hence where cool operations for long periods are desired the following windings can safely be used, giving a total of about 9000 ampere-turns for the two poles. Each coil is wound with 15¼ lb. No. 22 B. & S. gage enameled magnet wire in even layers, using a layer of paper every two or three layers to keep the winding even. Always test the coil for continuity periodically as the winding progresses, as this may save much labor and time. The No. 22 wire coils, connected in series, give 253 ohms resistance, and the current will be 0.434 ampere on 110-

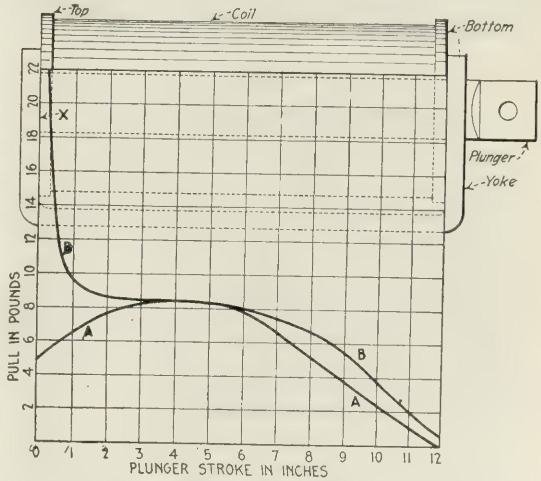


FIG. 5. SOLENOID CHARACTERISTIC CURVES

volt direct-current. The total pull is approximately 300 lb.

For semi-intermittent service, where a stronger magnetization is desirable, the coils can be wound with 151 lb. No. 20 B. & S. gage enameled wire. This gives a total of 15,430 ampere-turns. The resistance of each spool is 49.5 ohms, or 99 ohms for the two coils in series. The current on 110 volts is 1.11 amperes. The circular mils per ampere in this case are 920 or still in the safe operating field. For plain lifting or traction work use an armature of the same size as the yoke, or if iron plates, etc., are to be picked up, then these of course form the armature. By arranging the polepieces to suit, this magnet can be adapted to a wide variety of work such as for magnetic separators, operating various mechanical devices, etc.

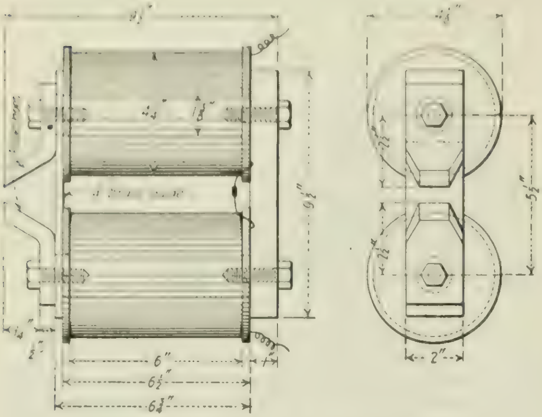


FIG. 6. MAGNETIZING ELECTROMAGNET

Electric Light and Power*

By Sidney Graves Koon, M.M.E.

In studying the census figures showing the growth of the electric light and power industry from 1907 to 1912 and 1917 there are many items of interest which do not appear on the surface. Some of these follow.

1. *The Unit or Average Plant*—The figures for 1907 show a total of 4714 "establishments" providing central-station service, this number increasing to 5221 in 1912 and 6541 in 1917. Dividing the principal items in the report by these figures, successively, the average plant appears to have grown as follows:

	1917	1912	1907	Per Cent. Increase 1907 to 1917
Total income	$80,551	$57,896	$37,260	116.2
Income from electric service	76,762	54,997	35,981	113.3
Total expenses	65,301	44,930	28,468	129.4
Salaries and wages	14,560	11,715	7,514	93.8
Persons employed	16	15	10	60.0
Primary horsepower	1,966	1,442	869	126.2
Kilowatt capacity	1,376	989	575	139.3
Output, kilowatt-hours	3,889,101	2,215,880	1,243,588	212.8

2. *The Financial Changes*—In 1907 the electric-service income ($169,614,691) represented 96.57 per cent. of the total income ($175,642,338). In 1912 the electric-service income ($287,138,657) represented 94.99 per cent. of the total income ($302,273,398). In 1917 the electric-service income ($502,100,346) represented 95.3 per cent. of the total income ($526,886,408). This left 3.43 per cent. for "all other income" in 1907, 5.01 per cent. in 1912, 4.7 per cent. in 1917. The growth of the electric-accessory business during the five years from 1912 to 1917 appears to have been more apparent than real, as measured in terms of energy consumption, for it failed to keep pace with the growth in income from electric service.

Total expenses in 1907 were 76.4 per cent. of total income. Whether these "total expenses" include taxes was not stated, but the expense ratio leads one to believe that the taxes were included. In 1912 the corresponding expense ratio was 77.6 per cent. In 1917 it was no less than 81.07 per cent. The evidence of steady increase in this figure is what would have been anticipated by anyone familiar with conditions in the industry. But the next deduction comes as something of a surprise—that the relative amount paid for wages has fallen as compared with total income and with total expenses. The table shows the ratios.

	1917	1912	1907
Salaries and wages	$95,239,954	$61,161,941	$35,420,324
Percentage of			
Total income	18.0	20.23	20.17
Total expenses	22.3	26.07	26.4

The average annual "pay envelope on 1907 contained $744, or $62 per month. In 1912 this had advanced to $771 per year, and, in 1917, to $902, or a little over $75 per month. The increase from 1907 to 1912 was only 3.63 per cent.; from 1912 to 1917 it was 16.99 per cent.; over the whole period, 1907 to 1917, the advance was 21.24 per cent. These figures were not enough, however, even combined with the increase of 121.6 per cent. in number of total employees, to bring the total payments up to the proportionate figure for earlier years, as compared with either total expenses or income.

Income from electric service, divided by output in kilowatt-hours shows an average of 2.893 cents per kilowatt-hour in 1907, falling 14.2 per cent. to 2.482 cents as an average for 1912, and a further 20.5 per cent. to the 1.974 cents of 1917. The total drop in "unit" income over the ten-year period was 0.919 cent, or 31.8 per cent.

3. *Primary Power*—The Census report gives the number of prime movers and the rated total horsepower of each of the three main types. A study of the change in average sizes shows some surprising figures for growth, when the briefness of the intervals is considered. The average steam engine in service has much more than trebled in size in ten years, while the average waterwheel has more than doubled. The gas and oil engines have actually diminished in average size. Thus:

	1917	1912	1907	Per Cent. Increase 1907 to 1917
Steam engines:				
Number	7,464	7,847	8,054	—7.3
Horsepower	8,389,389	4,949,778	2,693,273	211.5
Average	1,124	631	334	236.5
Gas and oil engines:				
Number	2,946	1,116	463	536.3
Horsepower	217,186	111,035	55,828	289.0
Average	74	99	121	—38.8
Waterwheels:				
Number	3,357	2,939	2,481	35.3
Horsepower	4,251,423	2,469,231	1,349,087	215.1
Average	1,266	840	544	132.7
Total prive movers:				
Number	13,767	11,902	10,998	25.2
Horsepower	12,857,998	7,530,044	4,098,188	213.7
Average	934	633	373	150.4

In spite of the slogan of "conservation," as applied to coal and fuel oil, the power derived from hydraulic

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*An analysis of the census figures for the United States, published in *Power*, Apr. 22, 1919, page 627.

plants scarcely more than kept abreast of the growth of the steam plants. The percentages of the total primary power furnished by each type of prime mover follow:

	1917	1912	1907
Steam engines	65.25	65.73	65.72
Oil and gas engines	1.69	1.47	1.36
Waterwheels	33.06	32.8	32.92

Steam turbines are of course responsible for most, if not all, of the great growth in aggregate horsepower of steam engines in the central stations. It is not unlikely that a positive decline has taken place in both the number and the total power of reciprocating engines engaged in this service during the decade under review.

The average capacity in kilowatts of the generators attached to each prime mover has increased from 246 in 1907 to 443 in 1912 and 654 in 1917; an over-all increase of 165.9 per cent. The total capacity of the plants, in kilowatts per person employed, has advanced from 57 in 1907 to 65 in 1912 and 85 in 1917—a gain in ten years of about 50 per cent. This is due in large degree, of course, to the heavy increase (150.4 per cent.) in the average capacity of prime movers. Quite likely the more general use of automatic stokers was another large factor in keeping down the number of employees.

The mechanical efficiency of the generating units showed a steady gain during the period, for the kilowatt capacity of dynamos per horsepower of prime movers advanced from 0.661 in 1907 to 0.686 in 1912 and 0.7001 in 1917, an over-all gain of 5.9 per cent.

4. *Output*—Based on 8760 hr. per year in 1907 and 1917, and on 8784 hr. in 1912 the over-all load factor showed a gratifying increase from 24.7 per cent. in 1907 to 25.5 per cent. in 1912 and 32.3 per cent. in 1917. This improvement is no less than 30.8 per cent., most of the gain coming in the most recent years. This shows well the fruits of the campaign continually being waged to "off-peak" business. It was also, in passing, doubtless one of the biggest reasons for the falling off in the average price of current per kilowatt-hour.

The output per person employed increased from 123,074 kw.hr. in 1907 to 145,826 in 1912 and 241,019 in 1917, a ten-year advance of 95.8 per cent. The growth in size of prime movers, already shown, is largely responsible for the gain of 246.7 per cent. from 532,943 kw.-hr. per unit in 1907 to 1,847,796 in 1917. The figure for 1912 was 972,031 kw-hr. for each prime mover.

Motors connected (aside from railway motors) more than trebled in number in the decade, and nearly doubled in individual average rating, having increased from 9.86 hp. in 1907 to 16.6 in 1917, a gain of 68.4 per cent. Motors appear to be taking a greater and greater share of the output of the stations. Figures for total conected load are not given, but the total motor horsepower was 71.7 per cent. of the total prime-mover horsepower in 1917, as compared with 54.9 per cent. in 1912 and only 40.2 per cent. in 1907. The ten-year gain in this ratio was 78.4 per cent.

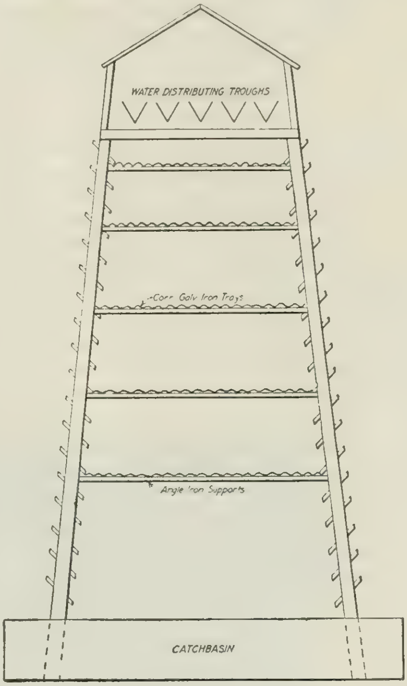
In the future the principal use of high-volatile coals will be in the byproduct gas plants because of the higher commercial value of the products of carbonization. It is even suggested that the time may come when our views of the relative values of the different coals will change and we shall consider anthracite as of minor importance as compared with the high-volatile bituminous coals.

Cooling Tower for Refrigerating Plant

By A. Giger

The following is a description of a cooling tower that has been giving excellent results. The sketch shows an end view of the tower with louvre boards removed to enable the reader to readily note its construction. The general construction is similar to that of many others in use, the chief difference being that instead of using the wooden crisscross, or checker-board, pattern for baffling the water, this tower uses the ordinary 26-gage galvanized corrugated iron, making a cheaper and much more effective means of cooling the water.

Water is pumped to the V-shaped troughs, having their upper edges notched like saw teeth, insuring a uniform distribution, provided the troughs are level and notches are of uniform depth. From these troughs the water falls to the corrugated trays, these latter completely covering their respective sections of the tower. The concave or gutter corrugations of these trays or galvanized sheets have holes punched in them, the size and distance apart depending upon the size of the trays and the amount of water that it is desired to circulate. In this particular tower the holes are $\frac{5}{16}$ x 4 in. centers, and were made with an ordinary belt punch and hammer. The water as it leaves the distributing troughs falls to the first tray, spreading and finding its way through holes down to the second tray, the second as well as the others being made the same as the first one, the water finally ending up in the catch basin, whence it goes to the condensers. Trays are kept in position by means of angle bars or timbers fastened to the tower frame. The water as it falls to the trays has no chance to accumulate or gather to any depth, but is more in the shape of a thin film; and owing to the trays being made of very light iron and the unrestricted passage of air through the tower, good results are obtained.



SECTION OF "HOME-MADE" COOLING TOWER

Operation at Holtwood—Features of Station Operation and Maintenance

BY CHARLES H. BROMLEY

A hydraulic operating board which bears the same relation to the governor and hand control that the benchboard and mimic board do to the 11,000- and 70,000-volt electrical system is located on the turbine-room floor and visible to the switchboard operator. Spare parts of hydraulic and electrical equipment are available to the crew without requisition or kep during emergencies. Vacuum in the turbine draft tubes used for cleaning the station floors. Many other interesting features are described and illustrated.

THE Hydraulic Operating Board—Midway of the turbine floor and directly across the floor from the switchboard gallery, is the hydraulic operating board, diagrammed in Fig. 2. This board bears the same relation to the governor- and hand-control systems as the benchboard and mimic board do to the 11,000- and 70,000-kw. buses. The operation of the pumps, headers, governor valves, etc., is always displayed on this board. The floorman makes the necessary indications whenever any pumps have been started, shut down or transferred, or when other changes in operation of the systems are made. The governorman makes the changes on the board following the shutting-down or starting of a unit; that is, he indicates the changes to the hand-contro and governor-control systems used for the particular unit. The operation of all governor pumps and of the No. 2 hand-control pump is indicated by red lights on the board. These lights are the same as are used on the electrical benchboard. The lamps are connected across the motor terminals. The board is made of 1-in. kiln-dried white pine, cleated, glued and framed; the dimensions are 15 x 6 ft. It is shellacked and given two coats of white-lead paint. Black stripes represent the piping connections. Valves are represented by oak buttons screwed to the board on top of ⅛-in. leather washers. When a button is in line with the pipe it indicates an open valve, and when set across the pipe it indicates that the valve is closed.

When valves, headers, pumps, etc., are cut out of service, and work is being done on them, a holdoff tag is hung directly on the operating board at the particular piece of apparatus or valve out of service. Likewise, when a main unit or an exciter unit is withdrawn from service for repairs, a holdoff tag is placed below the unit number marked on the board, while on the turbine itself the governor-control and the hand-control valves are locked, a painted iron holdoff tag forming a part of the lock chain.

One of the chief uses of the board is this: Suppose that the governor pressure is reduced considerably below normal. This will be shown on the large double-faced dial gages, one set of which is located in the turbine room and conveniently seen by the operator. A glance at the hydraulic board will tell the operator whether or not he has lost one of the governor- or hand-control pressure pumps, for if this pump is cut out of service due to disturbance on the electrical side, the red light on the board will have gone out.

Availability of Spare Parts in Emergencies—While a fully equipped stockroom is provided at Holtwood, and a stock clerk is in charge, care has been taken to make available to the crew at any hour of the day or night almost any

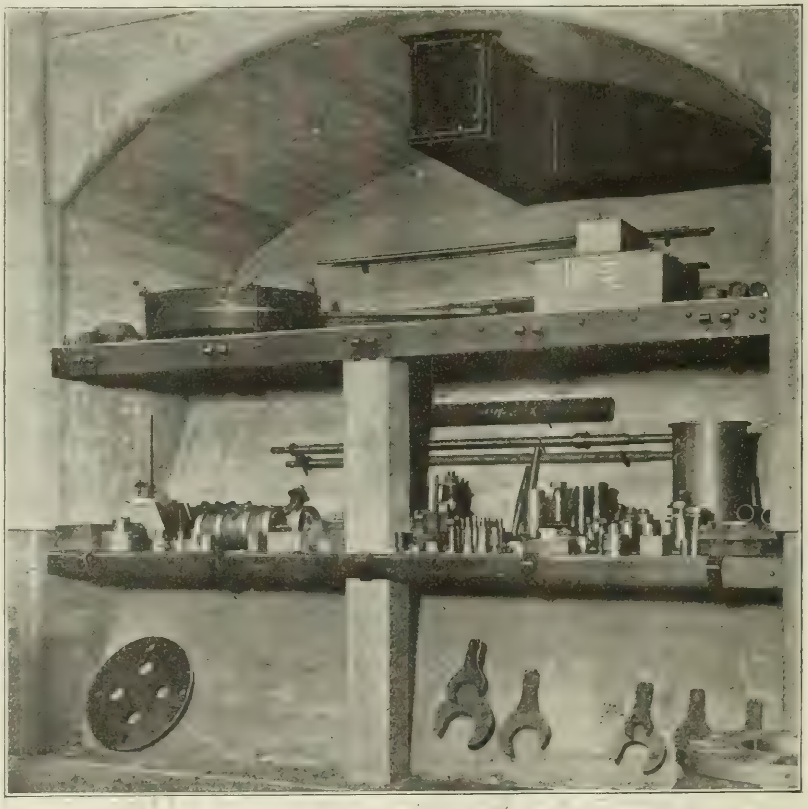


FIG. 1. SPARE GEAR IS AVAILABLE IN THE BAYS ALONG THE TURBINE ROOM FOR REPAIRS IN EMERGENCIES WHEN THE STOCKROOM CLERK IS ABSENT

part or tool needed to meet an emergency, without the necessity of making out a requisition and waiting until the stock clerk comes to unlock the large outside storeroom, whenever that might be. On shelves on the turbine floor, one of which is shown in Fig. 1, are found governor heads, trunnions, main valves, pilot valves, spindles, hydraulic operating mechanism pins, nuts, bolts and liners — in fact, almost any part that might be required if something went wrong with the hydraulic system during the night when the stock clerk or chief machinist was not on duty. The stockroom of the electrical gallery likewise has its parts—fuses, etc —available at all times. On Piney Island, where the arc extinguisher is located, spare parts are kept in a shanty and are always available for emergencies. In the bays along the main turbine room large sectional drawings of the unit opposite the bay are mounted in glass cases. These drawings show sections of the main units (that is, the turbine and generator) and one shows a section of the complete assembled governor.

Cleanliness and Order in Station—Cleaning of the principal apparatus and miscellaneous auxiliary equipment is assigned to specific station attendants, and their work is checked up by the entries on the "Annual Cleaning and Inspection Charts" mounted in a glass-front case on the station wall and described in an article on Holtwood records in the issue of May 20. This cleaning work is not the only plan employed to produce the neat and orderly appearance of the station that

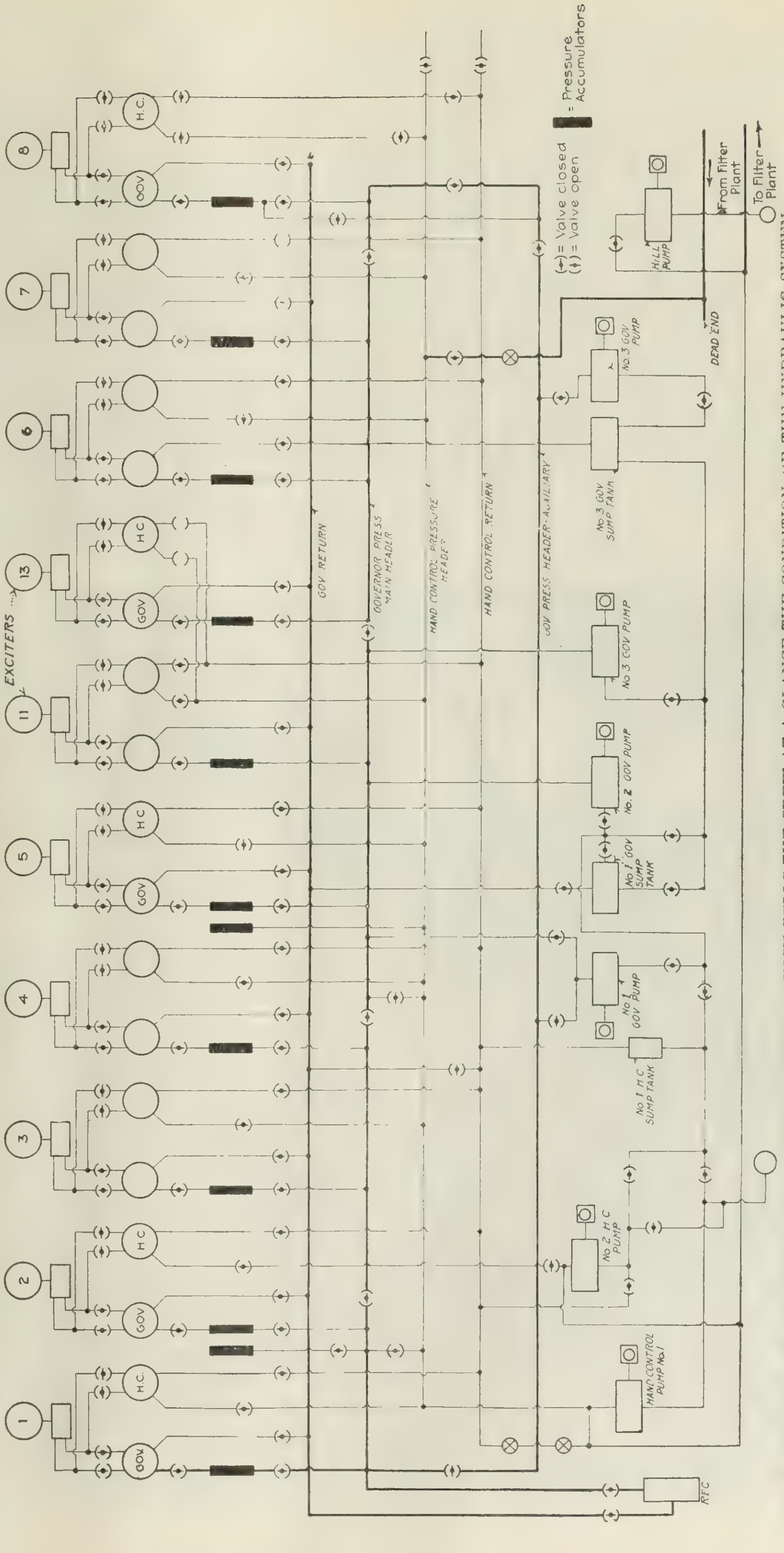


FIG. 2. DIAGRAM OF THE HYDRAULIC CONTROL BOARD, WHICH TELLS THE CREW AT A GLANCE THE CONDITION OF THE HYDRAULIC SYSTEM

impresses every visitor. Care is taken that all work around the station—handling of tools, sweeping of floors and stairways, chipping of concrete, etc.—is done in a manner that will not disturb the neat appearance of the station or interfere with operation.

For cleaning floors a vacuum system is used, connected to the draft tubes of the main turbines. The vacuum connections are provided at each unit on the main floor and at numerous other places throughout the station (see Fig. 6).

When chipping of concrete is to be done, canvas-covered wooden frames are placed around the workmen, preventing the fine dust from spreading over the station and penetrating into some of the exposed bearings of governors or auxiliary apparatus. How this is done is shown in Fig. 7.

Drinking water is provided at several fountains distributed at convenient places in the station. These are piped up through a circulating system to a small refrigerating machine, Fig. 8, thus doing away with sloppy ice-water tanks and handling of ice in the station.

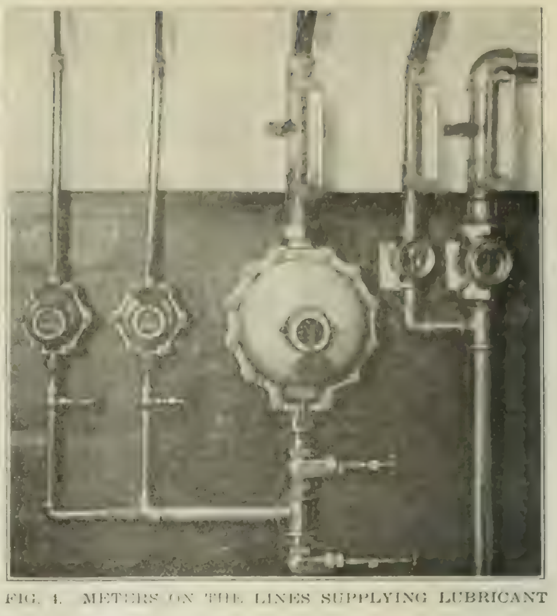


FIG. 4. METERS ON THE LINES SUPPLYING LUBRICANT

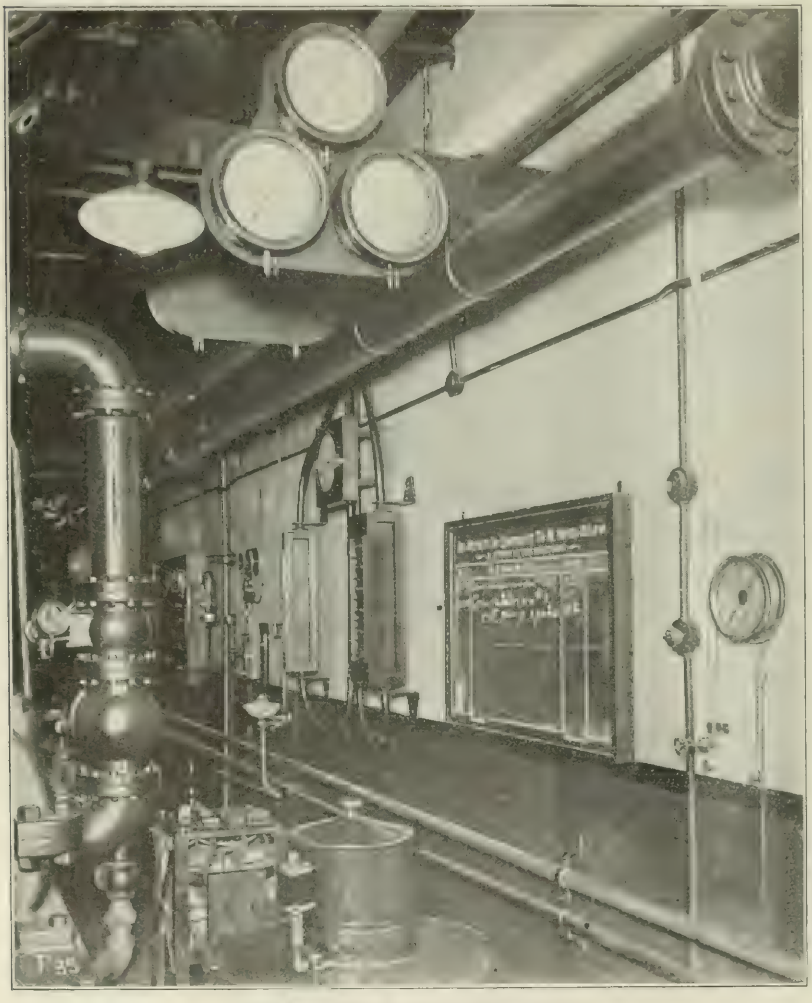


FIG. 5. VIEW IN THE PUMP TUNNEL

Dark corners, places around drains and cuspidors, etc., are painted a shining white, so that any neglect in cleaning such parts as are susceptible to uncleanliness will show up the more strikingly. Drain-cocks mounted on different apparatus are not permitted to cause leaky spots on the floor, or around the apparatus. They are piped up to small drain lines emptying into the trench or general drain provided on each operating floor. The writer noticed also that the large pipe lines in the pump tunnel, which carry cold water and which have given a great deal of trouble, due to sweating on humid days, have been coated with a layer of ground cork, which effectually prevents sweating. Small tools that are used frequently by operating attendants when performing minor maintenance work, are kept in a wire-glass-front locker, each tool having its place marked by a white line on the wall of the cabinet. This makes it practically impossible to return a tool to any place other than where it belongs, and the absence of any tool is noticed immediately through the glass front. Minor defects to equipment that cannot be taken care of by the operating attendant on shift, but are not so essential to safe operation as to require immediate correction, are noted on a blackboard in the pump tunnel. Columns are provided on the blackboard for the

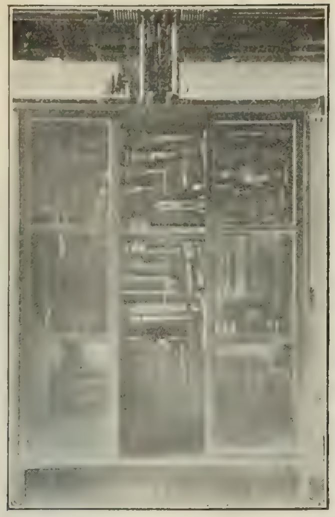


FIG. 5. WIRE-GLASS-FRONT TOOL CASE

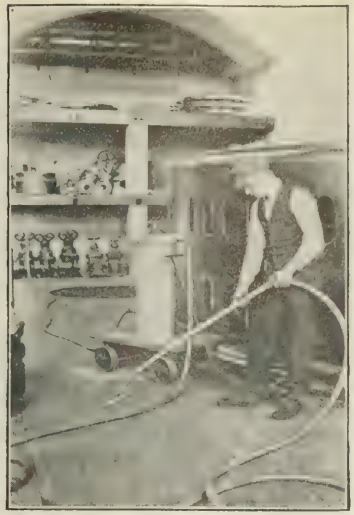


FIG. 6. USING THE VACUUM IN THE DRAFT TUBE FOR CLEANING

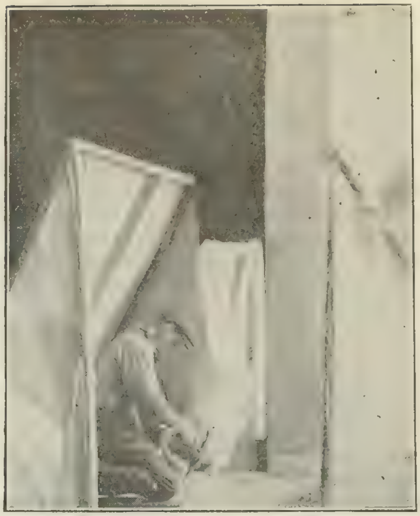


FIG. 7. FABRIC HOUSING PREVENTS THE SPREAD OF CONCRETE DUST

initials of the attendant reporting the defect and also for the man who corrects it.

Illumination—The man who has worked in a tunnel will immediately appreciate the value of a system of illumination whereby bright lights are not shining in his eyes. In the pump tunnel at Holtwood the main illumination is indirect; that is, the large or open ends of the shades point up to the roof of the tunnel, instead of facing the floor, as is customary.

While sockets and plug receptacles are well distributed about the plant for the use of extension lamp cords or drop lights, each man is furnished with a large electric pocket torch or lamp. These do much to eliminate guessing and hasty judgment in observation and inspection.

Observation of the Lubricating-Oil Flow—One does not have to be emphatic to convince the reader that the lubrication of these large turbines is important. The oil-supply and the oil-return pipes are of course provided with sight glasses so that the crew may tell at a glance whether or not the oil-pipe lines are obstructed. Oil-flow meters, thermometers and flow indicators are arranged as far as practicable in a compact group, well illuminated, permitting convenient and accurate observation. One additional little thing is done at Holtwood that the writer has noticed a lack of elsewhere —where these sight glasses are next to a dark wall the wall in back of the glass is enameled white. It is not likely, therefore, that the man making the observation will be mistaken, as the stream of oil is plainly visible, just as absence of the stream is indicated by a solid white background.

Precautions When Cutting in New Thrust Bearing—Roller bearings on the main units at Holtwood have not

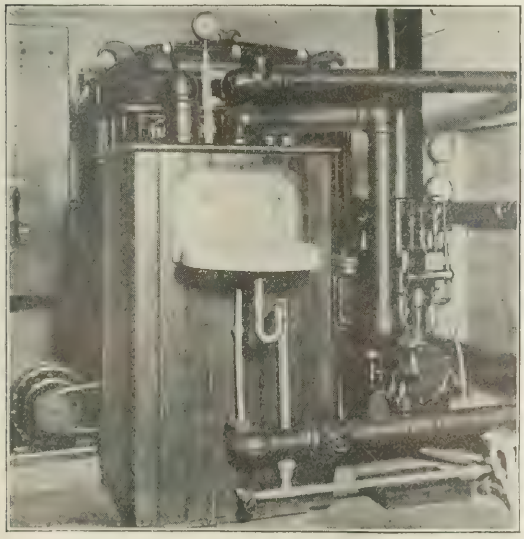


FIG. 8. THE REFRIGERATING MACHINE FOR COOLING THE DRINKING WATER

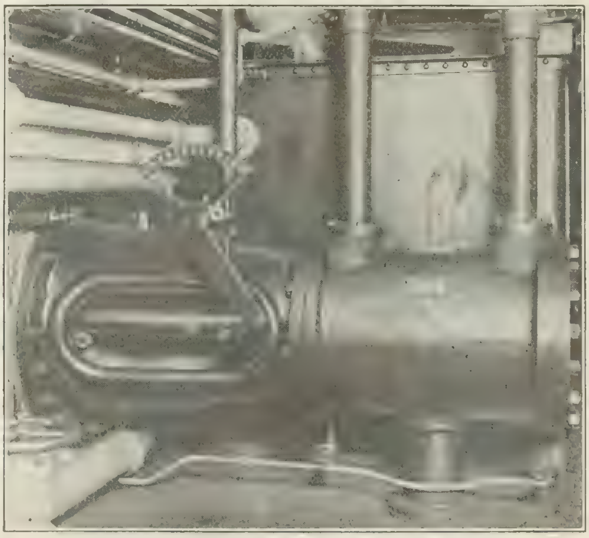


FIG. 9. OPERATING CYLINDER FOR MOVING THE GATES OF THE TURBINE. THE INDICATOR SHOWS THE POSITION OF THE GATES

been as successful as the operators would desire, and thrust bearings, in which the bearing surface is made up of a number of sectors resting in spherical seats and using an oil film at high pressure, have been provided. When first cutting in a new Kingsbury thrust bearing at Holtwood, the following precautions are observed: The floorman supervises the operation of starting and stopping the unit which has the new bearing in it. The temperature of the oil is closely watched for the first twenty minutes that the unit is running. During this time the temperature of the oil should not increase more than 2 deg. C. If it rises more rapidly, the unit is shut down and the chief operator is immediately notified. For the first thirty days that the unit is in service half-hourly readings of the oil temperature in the oil housings are taken and entered in a separate log sheet provided for this purpose. The unit is kept on hand control for a few days.

As most readers know, these bearings are designed to make use of the principles of lubrication made famous by Tower, who first discussed them before the Royal Society. The load is supported on a film of oil. For each of the 13,500-hp. turbines at Holtwood the total load on the thrust bearing is 410,000 lb., the speed is 94 r.p.m.; yet after six years' service the wear on the shoes is so slight as to be difficult of measurement.

The following data are from the tests on one of these bearings at Holtwood:

Total load on bearing, lb	410,000
Area of shoes, sq.in.	1,160
Unit pressure per sq.in., lb	350
Speed, r.p.m.	94
Mean surface speed, ft. per min.	900
Kind of oil	Light Mineral
Oil flow through bearing per minute, gal.	15
Mean temperature rise in oil, deg. F.	4.5
Frictional loss in bearing, hp.	9
Coefficient of friction	0.0008

Welding a Wrecked Rolling-Mill Engine Cylinder

By L. M. Malcher*

One of the big steel rolling-mill engines at the works of the Carnegie Steel Co., Farrell, Penn., which had been doing its full share in helping to win the war, broke down two weeks after the signing of the armistice, having worked constantly up to then on war orders. In the accident, besides other parts, the 54 x 70-in. left-hand low-pressure steam cylinder of a twin-tandem compound reversing engine was badly fractured, as a result of the breaking of a connecting-rod at the moment of reversal.

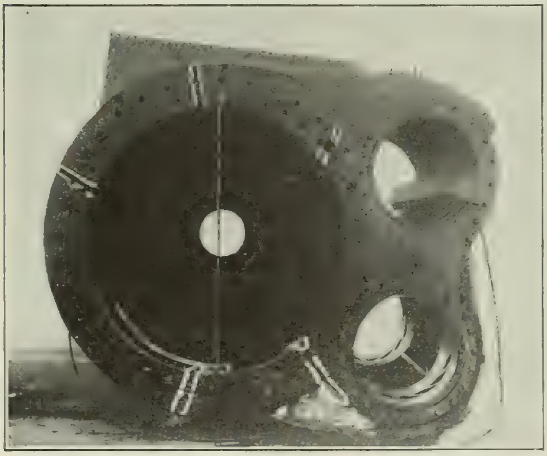


FIG. 1. WRECKED LOW PRESSURE CYLINDER, SHOWING CRACKS V-GROOVED BY CHIPPING PREPARATORY TO OXWELDING

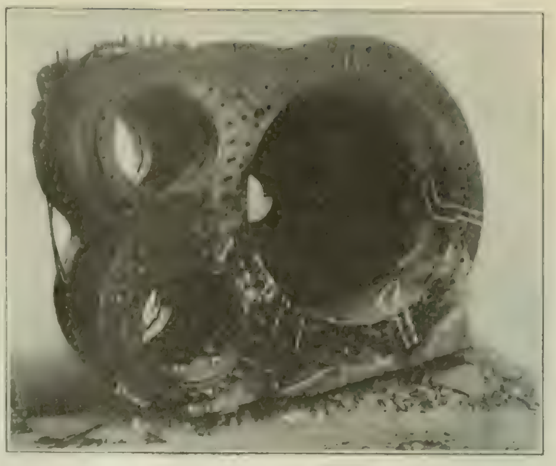


FIG. 2. WELDING OF LOW PRESSURE CYLINDER COMPLETED

A serious situation confronted the officials of the company as it would have taken three months or more to obtain a new cylinder. Three hundred and sixty men were thrown out of employment. The broken cylinder, in which there were seven cracks which totaled 22 ft. 2 in. in length, was of such size and the damage done was of such character that a decision whether the cylinder was to be renewed or repaired involved a risk on the part of the management. Although considerations of expense as between the cost of purchasing a new cylinder and repairing the old one were of secondary importance, the cost of repairing was estimated to be about one-third that of a new cylinder.

The officials of the company after investigation decided in favor of oxyacetylene welding. They called upon the job welding shop of the Oxweld Acetylene Co., Chicago, Ill., to meet the emergency. Three expert welders, accompanied by all necessary equipment, went immediately to Farrell and completed the job under the direction of the writer. The time consumed in repairing the cylinder, including chipping, preheating and welding, was 72 hours.

While dismantling the engine a fracture was discovered in the right hand, 42-in. high-pressure cylinder. This also was repaired in about 18 hours. It took just seven days from the time the order was given to complete the entire job.

While welding inside of the cylinder, the men relieved one another every ten minutes because of the extreme heat deflected back on them during the welding operation. On the outside welding, however, the heat was not so intense and the men relieved one another every thirty minutes.

After the engine cylinders were machined, it was almost impossible to determine where the cracks had been. The total cost of this repair represents but a small fraction of the replacement cost, but even this saving is insignificant when compared with the disorganization that would have resulted from the laying off of a large body of trained workmen and with the enormous loss that would have been caused by a stoppage of production.

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*Superintendent, Welding Shop of Oxweld Acetylene Co.

Fusibility of Ash From Pennsylvania Coals*

BY W. A. SELVIG AND A. C. FIELDNER

INTRODUCTION

PREVIOUS papers[1] gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash-fusibility tests, a discussion of the relation of fusibility tests to clinker formation, and tables giving a summary of results obtained for the coals of West Virginia and the interior province. This paper includes a table giving a summary of such tests on the coals of Pennsylvania, which state is by far the greatest coal-producing state in the union.

INTERPRETATION OF FUSIBILITY TABLE

The various coal beds of the bituminous coal field of Pennsylvania are arranged according to their geological succession, the uppermost beds being listed first. The samples tested are practically all standard mine samples collected according to the methods used by the Bureau of Mines.[2] A few car samples which were considered representative of the output of the various mines were also included.

The various coal districts of the anthracite region are arranged alphabetically under the field to which they belong. The samples are practically all delivery samples of the various sizes as marketed; only a few standard mine samples are represented.

The number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent. ash and per cent. sulphur on the dry-coal basis are given for each bed tested in the bituminous coal field and for each district in the anthracite region. Average values for each mine were computed from the individual samples, and from these values averages representing each bed or district were obtained. In some instances the average values given for the beds or districts represent only a few mines and are in such cases not truly representative. The point taken as the softening temperature is that at which the ash when molded into solid triangular pryamids ¾ in. high and ¼ in. wide at the side of the base, and mounted in a vertical position has fused down to a spherical lump. Samples remaining unfused at 3010 deg. F., which was the highest temperature attained in the test, were marked plus 3010 (+3010) and used as such in figuring the average values for the mine from which the average values of the beds or districts were computed.

DISCUSSION OF FUSIBILITY VALUES

As stated in a previous paper[2] on the fusibility of coal ash from the interior province coals, the softening temperature of coal ash from the various fields of the United States range in general from 1900 to 3100 deg. F., this range of softening temperature for convenience in discussion being subdivided into the three following groups:

Class 1: Refractory ashes, softening above 2600 deg. F.

Class 2: Ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3: Easily fusible ashes, softening below 2200 deg. F.

The softening temperature of the ash from the bituminous coal field of Pennsylvania are found in Class 1 and Class 2, principally in the latter. The beds of the Monongahela, Conemaugh and Allegheny series, with the exception of the Lower Kittanning, Fulton and Brookville beds of the Allegheny series, are uniform as regards fusibility and come in Class 2. The Lower Kittanning bed of the Allegheny series contains a large number of mines that give ash of high fusibility, and the average for this bed almost places it in the lower part of Class 1. The Fulton and Brookville beds of the Allegheny series, as also the Bloss bed of the Pottsville series, come in Class 1.

It is interesting to note that the coals that show high softening temperatures are geologically the lower and older beds of the bituminous coal field. This was also found to be true of the coal beds of West Virginia. It has been found that in general the beds of the Monongahela and Allegheny series of Pennsylvania give a more refractory ash than do the same beds as found in West Virginia.

The ash from the anthracite region of Pennsylvania is refractory, coming in Class 1. The softening temperature in practically every instance is above 3000 deg. F.

FUSIBILITY OF ASH FROM PENNSYLVANIA COALS

Series, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Deg. F.	Ash in Dry Coal, Average Per Cent.	Sulphur in Dry Coal, Average Per Cent.
Bituminous Region					
Monongahela Series:					
Pittsburgh Bed	10	34	2360	7.17	1.43
Conemaugh Series:					
Little Pittsburgh Bed	1	2	2390	8.13	1.70
Allegheny Series:					
Upper Freeport (E or Lemon) Bed	33	85	2350	9.35	2.13
Lower Freeport (D or Moshannon) Bed	21	70	+2390	8.52	2.06
Upper Kittanning (C Prime) Bed	7	18	+2350	8.67	2.16
Middle Kittanning (C) Bed	5	7	+2380	11.06	2.98
Lower Kittanning (Miller or B) Bed	39	162	+2550	7.86	2.03
Fulton bed	4	12	+2940	7.36	1.18
Brookville (A) Bed	3	3	+2800	12.98	1.86
Pottsville Series:					
Bloss Bed	3	3	2630	11.96	2.25
Anthracite Region					
Northern Field:					
Pittston District	1	1	+3010	6.03	0.58
Plymouth District	2	7	+3010	12.52	0.84
Scranton District	6	7	+3010	12.39	0.79
Wilkes-Barre District	3	4	+3010	13.17	0.78
Eastern-Middle Field:					
Hazelton District	1	1	2960	14.50	0.61
Western-Middle Field:					
Shamokin District	2	2	+2960	16.59	0.90
West Mahony District	3	3	+3010	.....	....
Southern Field:					
East Schuylkill District	2	2	2990	11.19	0.78
West Schuylkill District	1	1	2730	18.07	0.82

Note: A plus sign (+) placed before a given value denotes that the true value is above that indicated.

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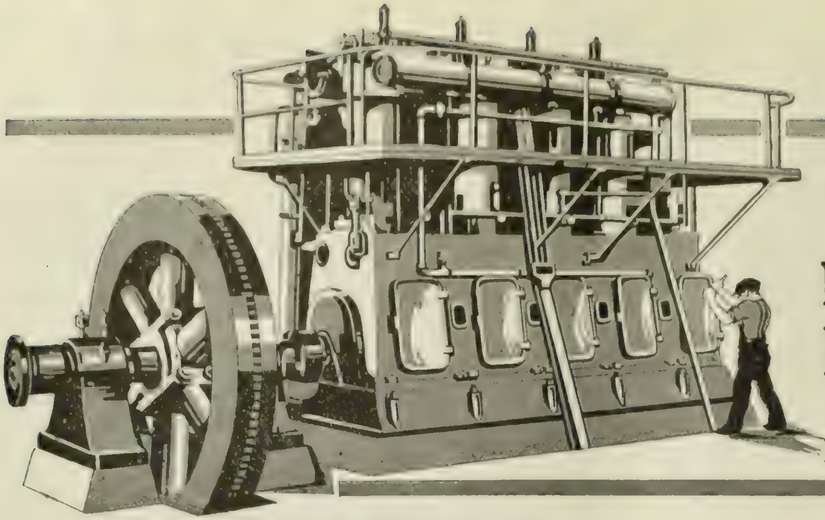
[1] Selvig, W. A.; "Fusibility of Ash from West Virginia Coals," *Power*, p. 566, Oct. 15, 1918; *Chemical and Metallurgical Engineering*, Vol. 19, No. 12, 1918, pp. 826-8.

Selvig, W. A., Ratliff, W. C. and Fieldner, A. C.; "Fusibility of Ash from Great Lakes and Mississippi Valley Coals," *Power*, April 1, 1919, p. 479; *Chemical and Metallurgical Engineering*, Vol. 20, No. 6, 1919, pp. 274-6.

For complete tables giving results obtained for each mine tested see: Selvig, W. A.; "Fusibility of Coal Ash from West Virginia Coals," *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16. Selvig, W. A., Ratliff, W. C., and Fieldner, A. C.; "Fusibility of Ash from Coals Found in the Interior Province," *Coal Age*, Vol. 15, No. 16, 1919, pp. 698-703.

[2] Holmes, J. A.; The Sampling of Coal in the Mine; Technical Paper 1, Bureau of Mines, 1911, 18 pp.



Talks on DIESEL Engines

by L. H. Morrison

XX—The chief brings to a close his series of informal talks, the subjects for the final meeting being the efficiency of the Diesel engine, as compared with other prime movers, and the necessity of keeping daily records.

"CHIEF," said Kelly, as Egan sat down at his desk, "you say that the Diesel engine is the cheapest power, and still you hedge."

"How so?" Egan smilingly hunted for a match.

"I heard you say to-day that a gas engine didn't use any more heat units than a Diesel."

"Those two statements don't conflict, Kelly. The gas engine might use less heat units and still be more expensive to run than an old slide-valve steam eater. You must look into the cost of the heat units to decide which is the cheapest. Even though the gas engine equalled the Diesel in thermal efficiency, it usually will be the more expensive to run."

"What do you mean by thermal efficiency?"

"That means the percentage of the heat supplied by the fuel that is actually used by the engine in developing power in the cylinder. The thermal efficiency of a Diesel will not exceed 38 per cent. in operation, though in factory tests 40 per cent. has been obtained. This, though, usually includes the extra power that the air injection supplies. The real meat of the affair is the efficiency per brake horsepower. The value that this will show in an engine in operation at around full load, is from 25 to 30 per cent. A good gas engine on full load will show up as well. On the lighter loads, the gas engine cannot equal the Diesel. The efficiency in either engine depends to a considerable extent on the compression pressures. In the Diesel this pressure is fairly constant at all loads, since a full air charge is drawn in even at low loads. With the gas engine, at low loads, the mixture of air and gas is leaner and the compression pressure falls off a corresponding amount.

"Fig. 1 shows the results of two tests we ran on a four-cylinder vertical 200-hp. gas engine and a four-cylinder 500-hp. Diesel, the gas-engine curve being the lower one. At full load the brake efficiency is the same, but at the low loads the Diesel shows up better. Taking the efficiency on the basis of cost, let's see how they pan out. Our Diesel fuel oil costs us 3.32c. per gal. Natural gas at the turbine plant is purchased for 8c. per thousand cubic feet. First, figuring on the Diesel, we find it requires 8380 B.t.u. per brake horsepower at full load. Oil costing 3.32c. per gal. means 0.4c. per pound of 18,000 B.t.u. Consequently, the cost per brake horsepower is $\frac{8380}{18,000} \times 0.4 = 0.186$c. or 1.86 mills. Checking the gas engine we find the gas contains 800 B.t.u. per cu.ft., and so 8380 B.t.u. would cost 0.084c. or 0.84 mill. The gas engine would therefore be the more economical."

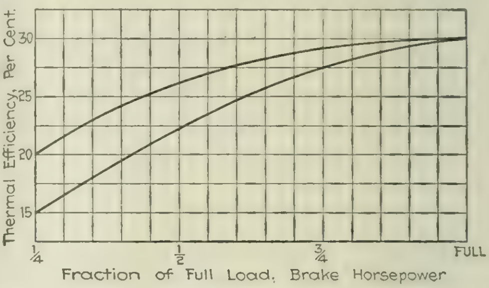


FIG. 1. COMPARISON OF DIESEL ENGINE AND GAS ENGINE PERFORMANCES

"That's pretty cheap for gas. It's costing me 50c. per thousand."

"That's because you are a domestic consumer, Woods. With a gas engine the consumption is not as great as in a steam plant, so the cost would exceed the 8c. which applies at the turbine plant where millions of feet of gas are used each month. A cost of around 25c. per 1000 cu.ft. ought to be about right for a gas engine. Since natural-gas and fuel-oil prices vary, as well as the B.t.u. per cubic foot of gas, we can strike a ratio between them. If A represents the cost of oil in cents per gallon (30 deg. Baumé, 18,000 B.t.u. per lb.)

then the cost per Diesel brake horsepower would be $\frac{8380}{18,000} \times \frac{1}{7.3} \times A = 0.0638A$ cents, the value 7.3 being the weight of a gallon of oil of 30 deg. Baumé. If the gas used in the gas engine has a heat value of 1000 B.t.u. per cu.ft., then to equal this cost it must not cost more than $\frac{0.0638A}{8380} \times 1000 \times 1000 = 7.61A$ cents per 1000 cubic feet.

"As a matter of curiosity, just see what you could afford to pay for fuel oil, if your natural gas cost 40c., which is quite a common figure in this state. Since the gas runs 800 instead of 1000 B.t.u., we get $40 \times \frac{1000}{800} = 7.61A$, or $A \doteq 6.56$c. per gal. If your fuel is of lower gravity than 30 deg. Baumé, of course you get more pounds per gallon, and naturally you can pay a correspondingly higher price per gallon.

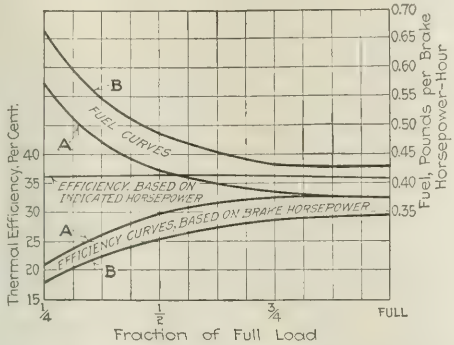


FIG. 2. RESULTS OF TESTS MADE AT FACTORY AND AFTER INSTALLATION

"Consider how impossible it is to think of using illuminating gas with its lower heat capacity and higher price per cubic foot. The serious competitor of the Diesel engine is at present the gas engine using waste blast-furnace gas. In the future, when oil becomes scarcer, the producer-gas engine will again demand consideration.

"If a real successful producer was manufactured that could be operated without the present troubles, the Diesel would have little chance. Such an engine can deliver a brake horsepower on 1¼ lb. of coal. If slack bituminous coal at $2 per ton could be used, the power cost would be less than with a Diesel. If the plan of installing coking plants at the mouth of the mine is ever carried out, the waste-gas engine will then be far the Diesel's superior for electric generation."

"But how about tests on Diesels? I heard you tell one salesman you wouldn't believe in any test."

"I confess I was stringing him, Kelly, but there was just a little truth in my remark, at that. A test doesn't show you by any means what you'll get in everyday operation. Everything is always given the best of care and conditions are practically ideal. It won't do to use test results in figuring on probable yearly operating costs."

Pulling out Fig. 2, Egan continued: "Here are the results of two tests run on a 500-hp. vertical engine. The curves marked *A* are the results of the factory test, while those marked *B* are the results obtained after installation. Mind you, I don't mean that the better values weren't actually obtained. They were, for our man was right on the ground, and I'd gamble that nothing could be pulled off on him.

"The efficiencies and fuel consumptions we obtained are, I believe, about as good as may be expected in any test after installation. The curves all show lower values than those in the factory test, but we must remember that a factory test is made under conditions that cannot be secured in a power plant."

"J. R., I don't understand that curve of thermal efficiency based on indicated horsepower. I always thought the smaller the load the more fuel used per horsepower," Woods ventured.

"That is true, Woods, especially if we are considering brake horsepower. In any engine a certain amount of power is required to overcome internal friction. If this loss is 20 per cent. at full load, there would be 100 friction horsepower in the 500-hp. engine. At half load, or 250 b.hp., the same loss of 100 hp. occurs, and the indicated horsepower is actually 350. Our thermal efficiency per brake horsepower is lower, but per indicated horsepower the efficiency is practically the same as at full load. This is to be expected, since the combustion does not depend on the richness or leanness of a gas mixture. The oil is injected at all times into a volume of excess air."

"Well, J. R., does the friction horsepower include the air-compressor load?" Woods continued in his desire to understand the curves.

"Yes, it does. But in my judgment the air compressor should not be credited to the friction load."

"Why so, Egan?" asked Kelly, who had been silent for an unusual length of time.

"The engine pulls the air compressor, furnishing the injection air. The air, as it blows the oil into the cylinder, helps to keep up the pressure within the cylinder. The indicator card is, as a consequence, of greater area, the expansion line being slightly higher. Then it is my opinion that the engine is getting something for nothing. We increase the indicated horsepower by the use of the air that is produced by the power we call lost. We can arrive at an accurate result as to thermal efficiency by one of two methods: First, we can disregard the indicated-horsepower thermal efficiency and judge our engine by its efficiency based on brake horsepower. A second method would be to figure out the power re-

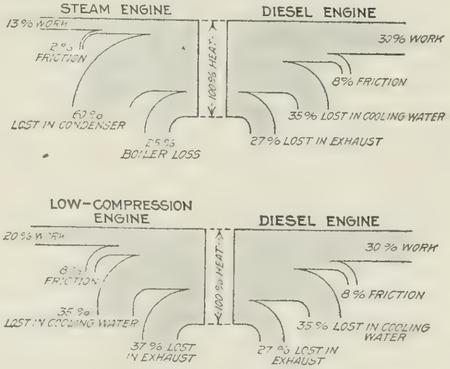


FIG. 3. HEAT DISTRIBUTION IN ENGINES OF DIFFERENT TYPES

quired to operate the compressor and to deduct this amount from the indicated horsepower as found by the indicator card, calling the new value 'actual indicated horsepower.' I'll admit this involves an error that could be corrected only by an estimate. It's this: Since part of the air actually is used in atomizing the fuel charge and in overcoming the resistance of the atomizer, this part has no influence on the indicator card. Probably making a fifty-fifty cut on the compressor deduction would be about right.

"Going back to the test we made, Fig. 3 shows the various losses and is the heat balance of the engine. I thought it a good scheme to show alongside of it the heat balance of a condensing steam engine. It's very evident why the Diesel is more economical since it actually uses twice as much of the heat supplied as does the steam engine.

"Since Wood is an ex-hot-ball man, I think the second heat diagram in Fig. 3 will wean him away from his old love. The best of the low-compression engines make use of but 20 per cent. of the heat supplied in the form of fuel and so it's impossible for such an engine to equal a Diesel in performance.

"One thing you boys must observe is the keeping of daily log sheets if you expect to know your operating expenses accurately. To be of value, the log sheet should show hourly readings of the electrical instruments, of the fuel consumed, of the inlet and discharge-water temperatures and of the pressure in the air bottles. In addition, there should be spaces provided for a daily record of the fuel on hand, amount received, amount used during the day's run, and the balance on hand at the end of the day. Similarly, there should be blank spaces for recording the number of quarts or gallons of engine oil, cylinder oil, crank-case oil, gasoline and kerosene used per day, and the number of pounds of waste. And of course there should be space for remarks, which would include reference to any unusual conditions, accidents, repairs, and explanation of extraordinarily high consumption of fuel oil, lubricating oil or other supplies. The size and arrangement of a log sheet will have to be adapted to the equipment of each particular plant, but a little ingenuity is all that is required.

"Now boys, we have discussed a lot of things about our daily work. I've done most of the talking. I hope you fellows, while doing the listening, have let some of it sink in. I may be wrong, but I think I see some results of our talks, in your work. The one thing every engineer must do to be successful is to think over what he is doing. Investigate the cause of everything that happens and if you are at sea, ask someone else.

"This is the last night I can meet with you for awhile. The planning of the new equipment and laying out of the plant addition will take up most of my evenings for some weeks. However, even though we do discontinue these gatherings, there is no reason why we shouldn't take a few minutes each noon to go over things. It's the Madame's prayer-meeting night, and I'll have to step lively if I get there before they all leave. So, good-night; and Johnson, keep plenty of oil on that air-compressor crank!"

The Electrical Study Course—Fundamentals of Brake Tests on Motors

Introduces the fundamental conception of power being the rate of doing work, as illustrated by the raising of a weight through a given distance in unit time, and goes on to a development of the fact that under all conditions the power delivered by a pulley is the product of its circumference, speed and the force at its face opposing rotation.

SUPPOSE a belt to be placed over a pulley and a weight be attached to it, as shown in Fig. 1. If the pulley be revolved in the direction of the arrow *A*, it will have a tendency to lift the weight *W*, but if the end *a* of the belt is hanging free, as shown, there will not be sufficient friction between the belt and the pulley to raise the weight off the surface it is resting on, unless it be very small. By attaching a weight less than *W* to *a* we could increase the friction between the belt and the pulley sufficiently to cause *W* to be raised, thereby imposing a load on the pulley that, expressed in foot-pounds per min., would be equal to the difference between the weights multiplied by the distance *W* is raised in one minute. The weight at *a* could be dispensed with if the belt were attached to the pulley as shown at *b* in Fig. 2, in which case there would be no question of slippage. If the distance *l* were very great, such an arrangement could be used to make an efficiency test on a motor, since the power output could manifestly be readily computed from the weight of *W* and the distance through which it was raised per minute, while the input could be obtained by measuring the voltage impressed upon the motor and the current taken by it, and multiplying the two together. As previously shown, efficiency $= \frac{\text{output}}{\text{input}}$, so that, having established the output and input simultaneously, we can compute the efficiency for the load on the motor at the time.

It would, however, be impracticable to conduct a test in this manner since the length *l* would have to be too great. Suppose, for example, that *l* is 314 ft., that *W* is 10 lb., that the diameter of the pulley, which we will call *D*, is 1 ft., and that it makes ten revolutions per minute. In one revolution it would raise *W* a distance equal to its circumference, and since its diameter is 1 ft., that would be 3.14 ft. Since its speed is 10 r.p.m., the distance through which *W* would be raised in one minute would be $10 \times 3.14 = 31.4$ ft., and in 10 minutes it would have traveled 314 ft. or the entire distance available. From this it can be seen that no continuous test could be made on the motor, and that if its speed were greater than that assumed, the interval for observations would be reduced. Thus, if the speed were 1000 r.p.m. instead of 10 r.p.m., the interval would be one-hundredth part of what it was, or, $\frac{10}{1000} = 0.01$ minute $= 6$ seconds. Hence, it is evident that, with even such a considerable depth of more than 300 ft., no test could be run.

Suppose, now, that instead of the arrangement of Fig. 2 we use that shown in Fig. 3. Here we have the same belt as in the former case, fastened in the same manner, but instead of getting a pull of 10 lb. by means of the weight *W*, we obtain it by pulling on the spring balance *c* until it registers that force. Assume, now, that, as the pulley revolves slowly, we follow it around as indicated in Figs. 4 to 6, always keeping just enough pull on the balance to make it register 10 lb. continuously. It is evident that under these conditions there would be exactly as much load on the pulley as there was in the case of Fig. 2, since it is revolving at the same speed against the same force; that is, 10 lb. It would have the advantage, on the other hand, of allowing the test to run on uninterruptedly for as long a time as desired, but it in turn would be impracticable owing to the impossibility of following the pulley around accurately while keeping a uniform strain upon the scale, for any length of time. In any event it would be applicable only in the case of very slow speeds, since it would of course be impossible to follow the revolutions of the pulley if it were running at any considerable speed. The point to be noted, however, is, that the power required of a motor driving the pulley would be exactly the same as that necessary to lift the weight of Fig. 2. In that case, the power was 10 lb. × 31.4 ft. per min., or 314 ft.-lb. per min.

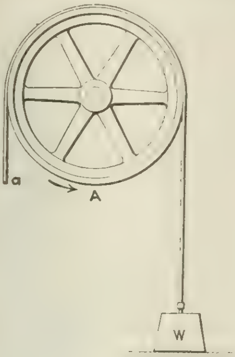


FIG. 1

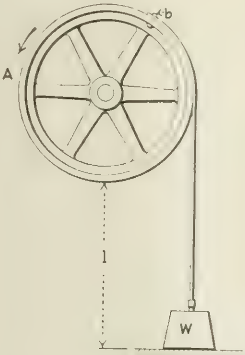


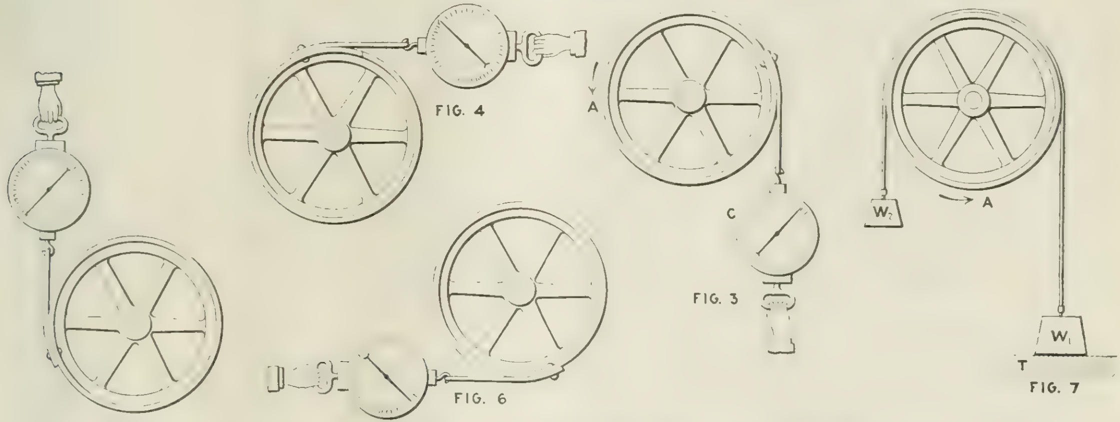
FIG. 2

Since the power developed in the case illustrated in Figs. 3 to 6 is the same, and since the pull is the same, it follows that the distance traveled against the pull is also the same. That is, in making one revolution, pulling against a force of 10 lb., a pulley 1 ft. in diameter would furnish 10 × 3.14 = 31.4 ft.-lb., and if it is making 10 r.p.m. it would be delivering 10 × 31.4 = 314 ft.-lb. per min., irrespective of whether it is directly lifting a weight of 10 lb. or only acting against a force of that magnitude imposed in some other way.

In general, we have the following relation: If *D* be the diameter of the pulley in feet, *F* the force in pounds acting at its face in opposition to its rotation, *S* its speed in r.p.m., and *P* the power it must develop to overcome the opposing force at the speed *S*, then $P = (\pi \times D \times S) \times F$ foot-pounds per minute. If it is desired to express the output in horsepower we divide by 33,000 ft.-lb. per min., so that if *P* represents the output in horsepower, we have, $hp. = \frac{\pi \times D \times S \times F}{33{,}000}$

To overcome the disadvantages of the methods of Figs. 2 and 3 to 6, we can adopt that of Fig. 7, the operation of which will be more readily understood in the light of the theory brought out in what goes before. Fig. 7 represents the same case as Fig. 1 except that a weight is shown attached to the left-hand end of the belt as well as to the right-hand one. Suppose that W_2 is made sufficiently great to cause the friction between the belt and the pulley to reach such a value that W_1 will be raised. Then the actual weight raised would be $W_1 - W_2$, and if the pulley is the same one as shown in Figs. 2 to 6, and is supposed to revolve at the same speed, we would have $P = (\pi \times D \times S) \times F = (3.14 \times 1 \times 10) \times (W_1 - W_2) = 31.4 \times (W_1 - W_2)$. If we assume W_1 to be 30 lb. and W_2 to be 20 lb., we have, $P = 31.4 \times (30 - 20) = 314$ ft.-lb. per min., as in the case of the 10-lb. force in the other cases. This method, employing the actual raising of W_1, would, however, be open to exactly the same objections as were found to apply to the method of Fig. 2, but we can modify the method so as to secure the same result and yet keep W_1 stationary by proceeding as follows:

First, W_2 can be made so small that there is insufficient friction between the pulley and the strap to raise W_1. Then weights can be added to it, causing the



FIGS. 1 TO 7. ILLUSTRATES PRINCIPLES OF MEASURING THE LOAD ON A MOTOR

pull on W_1 to become greater and greater. Finally a value of W_2 will be reached that will be just barely sufficient to relieve the support T of all the weight of W_1 without actually raising W_1 from it. Suppose that to satisfy these conditions W_1 and W_2 are found to be 25 and 15 lb., respectively. The pulley will then be struggling against a force of $W_1 - W_2 = 25 - 15 = 10$ lb., just the same as if W of Fig. 2 were actually being hoisted, or just the same as if the spring balance of Fig. 3 were trying to hold it back. The power that it develops will therefore be exactly what it was found to be in the previous cases, if the speed is 10 r.p.m. as before. In this case the retarding force of 10 lb. is due to friction of slippage between the pulley and the strap, whereas in the other cases it was due to work done in raising a weight or dragging around the arm of the person pulling on the spring balance. The difference is that in one case we have slip between a pulley and its belt and in the other we have none. When the latter work is performed, there is nothing to raise the temperature of the pulley, since no energy is consumed at its surface, whereas when the drag on the pulley is occasioned by the friction due to slippage, heat is generated and its temperature is consequently raised.

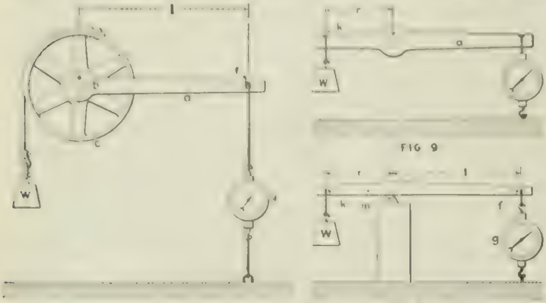


FIG 8 FIG. 10

FIGS. 8 TO 10. PROBLEM IN LEVERS

The method just described can actually be used, although certain modifications are desirable, since it would be a matter of difficulty to make the accurate adjustments of W_2 that would be necessary. Such a modified method will be presented in the next lesson.

The problem of the preceding lesson related to an arrangement such as that shown in Fig. 8. It was required to determine what the weight of W would have to be in order to cause f to pull upward with a force of 10 lb. on the spring balance g, if the diameter of the pulley c were 8 in. and the distance l were 2 ft. This is really a problem in levers. So far as the effect is concerned, the arm a might just as well be prolonged to the left as shown in Fig. 9, and the weight be suspended from it at k at a distance r from the center of the shaft equal to the radius of the pulley. We might represent this arrangement as a lever such as that shown in Fig. 10, in which m is the fulcrum and coincides with the center of the shaft of Fig. 8. A force equal to W pounds is applied at k and a force of 10 lb. thereupon is registered by g. The relation betwen the force at k and that at f depends upon the distances r and l. If we were to keep the distance r unchanged while we shifted f to the right or left, we should find that the force recorded on g would change and that it would become less as we moved away from m and greater as we moved toward it. That is, increasing l decreases the force at f, and vice versa. Also we should find that if l were made the same length as r that the reading of g would be equal to the weight W. That is, if the lever arms are equal, the forces will be equal. Since the force at f decreases when l is increased, it follows that it will be less than W if l is longer than r, and, conversely, that if l is shorter than r the force at f will be greater than W.

As a matter of fact the decrease or increase in the force at f is proportional to the increase or decrease in the distance l. Thus, if l be made twice r we should find the force recorded at g to be one-half the weight of W, or if it were made three times r the force would be one-third of W. So also if l were made one-half of r, the force at f would be twice the weight of W. Putting these statements into the form of a proportion and using F to represent the force at f, we find $W : F :: l : r$, from which we get $W = \frac{Fl}{r}$. It remains only to substitute in this expression the values of F, l and r given in the problem to determine W. The value of F is given as 10 lb. and that of l as 2 ft. Since r is the radius of the pulley, it is half the diameter, which is given as 8 in., making r equal to 4 in. It will be noted that r is given in inches, but that l is given in feet. To compare them they must be reduced to the same units, the simplest way being to express both in inches. We therefore have, $l = 2 \times 12 = 24$ in. and $r = 4$ in. Substituting in the expression for W, we have,

$$W = \frac{Fl}{r} = \frac{10 \times 24}{4} \quad 60 \text{ pounds.}$$

From the foregoing it is seen that if W weighs 60 lb. the scale g will register 10 pounds.

A 5-hp. motor is being tested by the method indicated in Fig. 7. Its pulley diameter is 8 in. and its speed at full load is 1200 r.p.m. If the weight W_1 is 100 lb., what would the weight of W_2 have to be to impose full load on the motor?

Courtesy, tolerance, and sympathetic understanding constitute the "Three-In-One" lubricant of business life. A man who is courteous may not get along with his associates, because his very coolness, a certain element of veiled sarcasm, or an air of evident superiority, may irritate those about him. He must be *more* than plain courteous. He must be tolerant with that willingness to permit other people to entertain their own ideas, even if they differ from his own. He must be tolerant with that broadmindedness which admits that *his* viewpoint is but one—and there are many others. But he may be courteous and tolerant, and still lack that winning quality so necessary to call out the best in those about us. For this purpose he must possess sympathetic understanding—the ability to appreciate why some people do and do not do certain things; why other people have a right to self interests of their own, and hopes, and ambitions—and fears. Ah, yes! The man who possesses courtesy, and tolerance, and sympathetic understanding, is vaguely described by others as having tact and personality, and as being a good mixer. Stop and analyze the elements of these terms of approval, and you will find that they are not mysterious or difficult. You and I may have them if we will!

EDITORIALS

High Steam Pressures

WHILE enthusiasm has abated, the determination to use higher steam pressures has become more intense. After consideration of other than entropy diagrams, after a survey of what difficulties of materials and operation lie along the road to the goal, engineers are now getting down to "brass tacks" in their efforts to overcome these obstacles. Their slogan is, "The efficiency of our power stations must be increased." And they are just as emphatically confident that the shortest and most efficacious route to this end is by way of high steam pressures.

The limitations of boiler steel are the stumbling blocks in the path. At about seven hundred degrees Fahrenheit the strength of the material seriously lessens. As steel is not an absolutely homogeneous mass but a mixture of crystals and metalloids which even the genius of Hatfield has so far not united in absolute union, and as reduction of the present factor of safety for steam vessels is unthinkable, the boiler problem in the quest for higher steam pressures continues to be a serious one.

Piping to carry pressures far above those now common is available. Welding will do considerable in eliminating leaks and similar troubles. Turbine builders say they are ready to furnish machines for practically any pressure that a boiler may be made to produce. They are waiting for the boiler. Turbines would likely step down the pressure in a comparatively few stages in a rotor of small dimensions. From this point on, the handling of the steam would present no more serious difficulties than are met in large turbines now operating in everyday service.

The economizer in its present form is getting along well under a pressure of two hundred and seventy-five pounds, but one does not want to risk life and property on cast iron for pressures much higher that this. So likely multistage economizers, something after that described in *Power* of April fifteenth, this year, and designed by Sargent and Lundy for the Kansas City power plant, will be used.

At the meeting of the Prime Movers Committee of the National Electric Light Association, held recently at Atlantic City and printed in part elsewhere in this issue, higher steam pressures received hopeful attention. At this meeting Oscar Junggren, turbine designer with the General Electric Company, pointed out that inasmuch as at the low-pressure end of the cycle engineers had reached the practicable limit because of the limitations of condensing water, the only way to increase the temperature range was by raising the higher limit. He discouraged the use of high superheat, urging that the desired total temperature be striven for by increasing the pressure, the aim being to minimize the heat rejected to the condenser. He made the significant statement, too, that for the higher pressures contemplated, "—the turbine probably will look much different than it does today, operating under about two to three hundred pounds." Perhaps he had in mind his colleague, Mr. Emmet's, mercury-vapor power plant, and then maybe he did not.

Richard Rice, of Lynn, who has taken a keen interest in higher steam pressures, urges that the air for combustion be used to reduce the flue gas from the temperatures now common to one hundred and fifty degrees. This with higher pressure will, he believes, increase the thermal efficiency of power plants from the eighteen and nineteen per cent., now good practice, to twenty-five and twenty-eight per cent.

The Daylight-Saving Law

DAYLIGHT saving was again in danger, through the efforts of the Agricultural Committee of the House of Representatives, until the Rules Committee declined to report a special rule giving the daylight-saving repeal parliamentary status as a rider to the Agricultural Appropriation Bill, thus assuring that the law will not be repealed at least during the present summer months. It would be amusing if it were not pathetic to see how many people feel that they have been deprived of some liberty when they are asked to comply with a ruling that may cause them to deviate from the cobweb-covered practices of the past irrespective of the economic value of the change. This is just the condition in many cases today regarding the daylight-saving law. From certain classes we hear complaints of the serious effects of shifting the clock ahead one hour. If these same individuals were kept from sight of a clock for twenty-four hours, they could not guess within an hour of the correct time.

Let each one look at this question from an economic viewpoint and not from any petty imaginary grievance. Is this change in the time economically beneficial? If no other country except our own has shown a disposition to go back to the old and more wasteful schedule, why is it so? In Europe the economic problem is far more serious than in this country; the people are facing a war debt that is staggering, with industries that are restricted or practically destroyed, yet they find daylight saving a good thing economically. In this country, where the effect of the war has been to increase our wealth and build up our industries, is it possible that we wish to keep right on in the old wasteful way?

The economic value of daylight saving is very difficult to estimate. One central-station company operating in a city of 760,000 population estimates that its gross revenue was reduced $350,000 last year due to daylight saving; but its coal bill was also greatly reduced. While this may represent a loss to one industry, it is an economic saving to the country as a whole, in the form of a reduction in electric and gas bills and the conversation of thousands of tons of coal. On the foregoing basis it is fair to assume that the total saving to the country as a whole in electric-lighting cost was not less than twenty-five million dollars, last year, and when the reduction in gas bills is added to this, the total saving is not far from fifty million dollars.

Are the millions who form the great industrial, commercial and professional army of this country to be called upon to pay a tax in increased electric-light and gas bills and have their hours of daylight recreation shortened for all time just to alleviate a grievance, on the part of the farmer, that is at least ninety-five per cent. imaginary, and to satisfy his desire to continue in the practices of antiquity? It might be well for the farmer to remember that his success today is dependent on the vast industrial centers that have grown up in our country and that although those who live in our cities and industrial centers look to him to supply them with a major portion of their sustenance, nevertheless practically everything that he has today to make life pleasant in the rural districts has come to him through our great manufacturing industries. Therefore the proposition is a reciprocal one, and with the farmer on the debtor's side of the ledger. Consequently, the multitudes who live in cities, towns and suburban districts are justified in opposing a tax that amounts to millions of dollars per year and represents an economic waste in the form of increased electric and gas bills, to satisfy the notions of another class. If this law is to be repealed at all, it should be by an act that some Congressman has the moral courage to father. The repeal should not be put over on the public by sneaking it upon the statute books by the back-door method in the form of a rider on some other bill. Let the Calder Act be given a fair trial, and if it is found to be detrimental, then let it be repealed on its merits and not by any camouflage scheme.

Power in Factory Cost Accounting

WITHIN a comparatively few years the importance of cost accounting has gained wide recognition, and it is to be doubted whether there is a progressive manufacturing establishment today that has not installed, or is not at the present time installing, such a system of accounting under the supervision of a competent executive. It is recognized that the value of a cost-accounting system is twofold. It determines actual costs of manufacture and so provides data upon which the sales department can base its quotations, and it is a means of determining where economies can be effected and whether a change in process actually does effect the economy anticipated. To provide the information thus demanded, it is the duty of the accounting department to analyze every detail entering into the cost of the manufactured product from raw material to taxes.

One of these items—and one that perhaps does not always receive the attention that its importance merits—is the cost in dollars and cents represented by the power that is used in the production of a manufactured article. To arrive at such costs is frequently a task of some magnitude, particularly when a factory embraces many departments. Nevertheless, it is requisite that means be provided for ascertaining them.

In such factories as operate an isolated power plant, the first point to be determined is, naturally, the cost of power per unit generated. Most often the power generated must be divided into two general classes, steam power and mechanical power. The former may consist of steam used for the heating of buildings and steam used in processes, such as boiling the contents of kettles or heating drying ovens. The mechanical power may be furnished through the medium of engines or through that of electrical generators or through both. In any event it is incumbent upon the accounting department to segregate the various types of demand and establish the cost rate of each. In this, the engineering department must be looked to to supply accurate operating data, from which the rates can be determined after making due allowances for the overhead charges that apply.

To secure reliable information regarding the operation of a power plant requires the installation of numerous measuring instruments, and it is the duty of every operating engineer who is not provided with them to represent the impossibility, to the accounting department, of accomplishing results without them. Where it happens that the accounting department makes an elaborate analysis of costs of power based upon records that are themselves unreliable, the result is manifestly a mere waste of effort and money to no tangible end. The fact that stands out is, that not only must instruments be provided, but they must be reliable ones. In addition to these, the equipment should comprise standards or semi-standards for the purpose of testing and calibrating the instruments in service. In this connection a regular system of maintenance and periodic testing should be developed and rigidly enforced.

In factories of recent construction the requisite details can and are provided for in the original layout, but often we have to deal with the plant that has grown up from a small beginning and to which additions have been made promiscuously without reference to any general policy of development. Such present the most difficult problem in regard to cost accounting, and require coöperation between the engineering and the accounting departments.

Sectionalizing the Underfeed Stoker

BUILDERS of underfeed stokers of the multiple-retort type have made praiseworthy improvements by providing their machines for sectional drive wherein the total number of retorts are divided into sections of a few or several, depending upon the total number, each section capable of being stopped, started and operated without interference with the operation of other sections.

This improvement will give a flexibility of movement of incoming coal and fuel bed to accomplish results which even highly skilled operators find it difficult to attain with a stoker the retorts of which are not sectionalized. In some recent installations consisting of thirteen-retort stokers, the stokers are in four sections each, each section driven by its own motor. Another installation of seven-retort stokers has each stoker divided into two sections. In the United States Nitrate Plant Number Two, described in the March Twenty-fifth issue, the fifteen-retort stokers are divided into five groups of three retorts each, one adjustable-speed motor driving each stoker, any one of the five groups of retorts being thrown in or out of motion by use of clutches.

One company is dividing its seven-retort stokers into three sections each, and has developed two methods of driving them. In one drive three four-speed motors are used; in the other, one four-speed motor with three two- speed power boxes.

The improvements are among the many developed to reduce the errors and shortcomings of the human element by making it easier to do the right thing than the wrong thing.

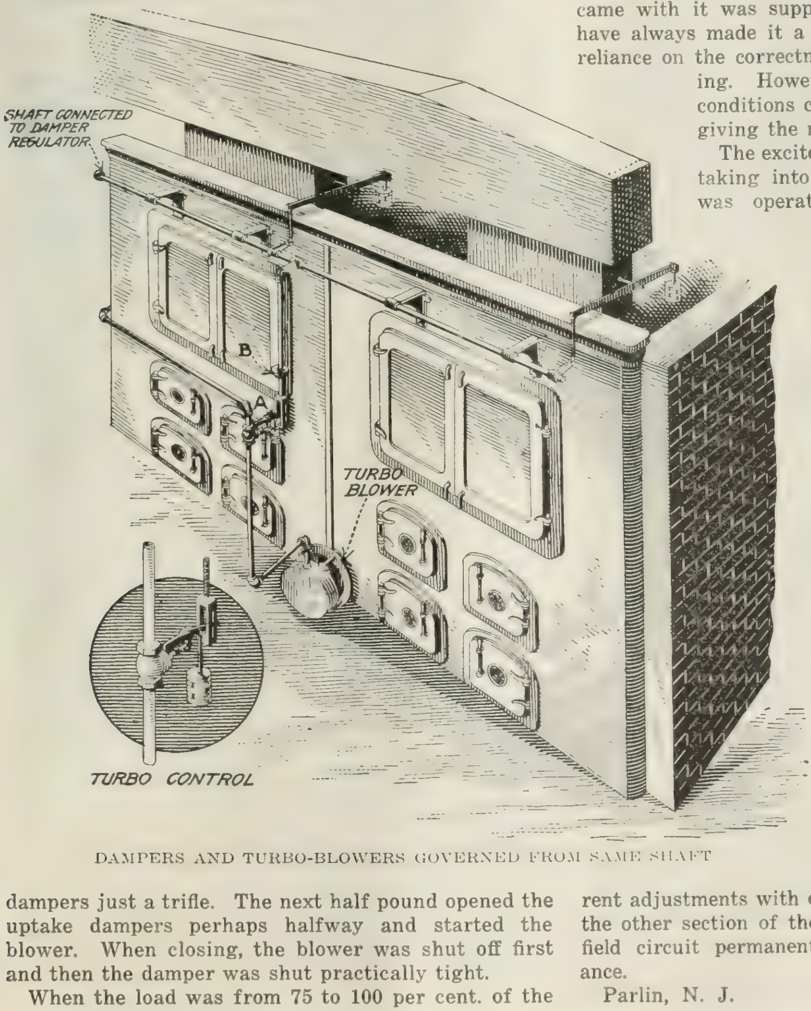
• Correspondence •

Damper and Blower Control

It was my pleasure some time ago to visit a small steam plant in which a turbo-blower was installed midway between two 6-ft. diameter horizontal boiler fronts. A steam damper regulator had controlled the draft through the medium of a horizontal shaft bracketed to the fronts of the boilers and connecting with the uptake dampers. The control of the turbo-blower was also taken from this shaft, as shown in the illustration.

Two clevises were introduced between the bell-crank lever on the steam-control valve to the turbo-blower and the lever on the shaft. Lost motion was introduced into the clevis on the bell crank *A*. There was also an adjustment *B* in the rod to lengthen or shorten it. The method of operation was excellent.

When the pressure dropped about one-half pound, the damper shaft turned slightly and opend the uptake dampers just a trifle. The next half pound opened the uptake dampers perhaps halfway and started the blower. When closing, the blower was shut off first and then the damper was shut practically tight.



DAMPERS AND TURBO-BLOWERS GOVERNED FROM SAME SHAFT

When the load was from 75 to 100 per cent. of the boiler capacity, the blower was in operation practically all the time, but on a light load the reverse was the condition. By means of the handwheel adjustment a balanced draft would almost obtain. As an upward motion opened the dampers, by pulling down on a hand chain the damper was closed on either boiler.

All in all this was, in my opinion, a very efficiently operated control. The engineer said that the control valve for the turbo-blower came with straight lever, but that it didn't seem to fit in his calculations, so he made a new lever of the bell-crank variety.

Waltham, Mass. C. W. Peters.

Exciter Difficulties

Recently, I put into service an exciter that developed very peculiar characteristics. This machine was purchased second-hand and the auxiliary equipment that came with it was supposed to be correct, although I have always made it a practice not to place too much reliance on the correctness of equipment without testing. However, in this case the operating conditions could not be determined without giving the machine a trial.

The exciter gave very satisfactory results, taking into consideration the fact that it was operating under severe conditions, being in parallel with three other machines of different design and manufacture, one a four-pole interpole unit, one a two-pole interpole type and one a four-pole noncommutating-pole machine. The field rheostat was very sensitive, and the slightest movement of the handle to increase or decrease the field strength produced very broad results, a minimum variation of about 20 per cent. full load. An investigation followed and it was found that the rheostat was of the two-unit type, both units connected in series with the shaft operating both arms at once, thus cutting in or out twice the resistance between each contact, causing abrupt changes in the regulation of the load. This operation was equivalant to operating two independent rheostats at once. Future trouble was eliminated by making the field-current adjustments with one section of the rheostat only; the other section of the rheostat was connected in the field circuit permanently as a constant fixed resistance.

J. W. Truesdell.

Parlin, N. J.

Neglected Cooling Towers and Cooling Ponds

Now is the proper time to give attention to cooling towers and cooling ponds, making all necessary repairs, changes or additions, so that the maximum cooling can be realized during the hot weather.

It is surprising how some of the larger installations are allowed to go to rack and ruin. In one instance the cooling towers were inefficient due to the following causes: Water unequally divided among five towers, where two towers received too much water and the other three received too little. The towers receiving an excess amount caused the water to enter the distributing boxes with such velocity that it splashed out at the points of discharge, which robbed certain areas of water.

Troughs leading to the V-notch pans were in many instances either out of place or knocked off, thus causing a large portion of the pans to be dry and large areas of the tower to be useless. Furthermore, the V-notch pans were not level, and this caused the water to flow to one side of the tower only, the other side being completely dry.

In the case of the V-notch pans out of place, the water ran in an unbroken stream to the bottom of the tower without being cooled. It was supposed to drop on board checkerwork or boards arranged vertically so as to form a film of water on their surfaces. Forced-draft fans at the bottom blew air up through these surfaces and cooled the water when properly distributed.

Another trouble was that the forced-draft fans operated too slowly on damp days and too fast on dry days. They did not take into consideration that most (one authority says 90 per cent.) of the cooling is due to evaporation of the water cooled, hence on cloudy, humid days the fans should be operated at maximum speed, and on clear dry days they need not be run nearly so fast.

Hot bearings, due to flexible couplings being in bad repair, caused certain fans to be shut down for periods of 10 to 12 hours out of the 24. Belt slippage caused when the attendant allowed water in the bottom reservoir to get so high that it overflowed into the fan housing and the blades threw it on the belt. The water also broke the fan blades, compelling a shutdown and repair expenses.

So little intelligence was exercised in the operation of these towers that the fans were actually run faster at night than during the day, and they were usually not speeded up in the mornings until 9 or 10 o'clock, when the injection temperature of the water rose so high that the vacuum dropped 1½ to 2 in. on the 8000-kw. turbine. On many days the operation was so bad that the vacuum dropped as much as 4 inches.

The attendants often went home without the shift chief's knowledge. In fact, the job was so soft that one man was found to be holding down an 8-hour shift in another plant. Five repairmen spent a great deal of time on the cooling towers resting, shooting crap and matching coins—charging all this time against the cooling towers and the power plant.

The remedy for most of this inefficiency would have been the employment of an expert engineer to look after this operation, also the use of such recording thermometers as would enable him to keep a tab on the various towers.

The cooling pond was inefficient due to the following causes: The spray nozzles were partly clogged with chips, etc., and insufficient spray nozzles made it necessary to maintain pressures varying from 12 to 17 lb. Furthermore, the nozzles were too large (2½-in.) and better results would have been obtained if 2-in. nozzles had been used. They were set too close to the water and better cooling would have been secured if the sprays had been elevated. Another fault was that the spray pond was located in a hollow, whereas cooling of water is decidedly easier when the pond is exposed on all sides to the winds. Screens to the suction well were not properly designed so as to make it possible to remove all accumulations of sticks, leaves and other rubbish.

A spray pond is generally not subject to misoperation to the extent that a cooling tower installation is, however, I might mention that the cooling towers held the injection temperature from 2 to 6 deg. lower on warm, humid days than the spray pond. Under normal conditions the cooling towers required approximately 300 hp. to drive the forced-draft fans. The discharge head of the circulating pump was also nearly ten feet greater in the cooling-tower installation.

Franklin, Ohio. WALDO WEAVER.

Wrong Connections to Slip Rings Caused Reversed Rotation

The direction in which a rotary converter will turn, when starting from the alternating-current end, depends on the direction of rotation of the magnetic field that starts it. This in turn depends on the order of applying the polyphase voltage to the armature, just as the direction of rotation of an induction motor depends on the order in which the supply wires are connected to the stator terminals. In either case the direction of rotation can be reversed by the interchanging of two of the supply wires.

A certain synchronous converter had been in operation so long that the collector rings had worn too thin to be safe, so it was decided to replace them. The new rings were furnished by the manufacturer of the converter, but were installed by the operator. On the first occasion of starting the machine, the rotor started in the wrong direction. As no connections had been disturbed except the internal ones to the rings, the trouble was properly attributed to the armature leads having been replaced in the wrong order to the rings.

Ordinarily, such a mistake is unlikely to happen, because completed leads are of such a length that the terminals of each will just reach the rings to which they should be connected. In this particular instance, however, new leads had to be made and installed, and the man who removed the old leads had to leave the job without completing it. It was necessary for his successor to make a guess, and the guess proved to be a wrong one.

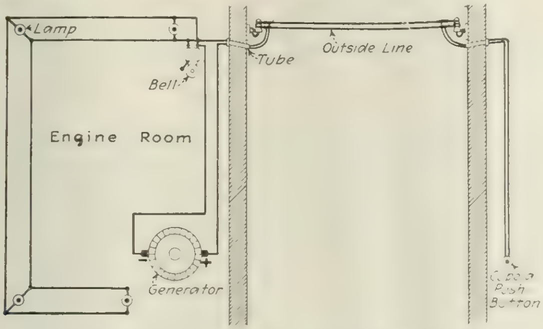
Fortunately, however, two of the armature leads were long enough to reach the farthest ring and their interchanging restored normal rotation. This is only another instance that goes to show the necessity of carefully marking all connections, when they are disconnected, so that anyone who may be called in to complete the job will not have to guess where the connections should be made. This in many cases will save not only unnecessary delays but often considerable expense.

Brooklyn, N. Y. E. C. PARHAM.

A Reliable Signal System

The transmission of signals for air from a foundry cupola to the engine room, where the blowers are often located, is attended with more or less delay, to say nothing of occasional misunderstandings that call for explanation. In many plants the foundry cupola is at a considerable distance from the engine room, which also complicates matters.

In a power plant that consists of a 350-hp. Corliss engine and a 25-hp. engine both direct-connected to blowers and attended by the same engineer, there was also an air compressor and two electric generators, all contributing to the noise that made it difficult to receive signals either by a gong or telephone. A reliable and flexible signal system was installed by using the following arrangement:



WIRING DIAGRAM FOR SIGNAL SYSTEM

Near the cupola was placed one of the best push-buttons made, with good heavy contacts, so that the signals could be given with certainty. Around the cupola, where the wire was subjected to comparatively high temperatures, slow-burning insulated No. 14 wire was used; beyond this and across the yard weatherproof insulated No. 14. The wiring was installed as securely as for any lighting circuit, the joints soldered and properly taped, tubes placed in the walls and the whole system well insulated. This arrangement has practically eliminated all troubles. Where the line would be exposed to ice and snow, it would be good policy to use a No. 10 wire across the yard. Plenty of copper is a good feature, as it keeps downs the volts drop in the line.

In the engine room the line was connected through a 10-in. fire-alarm type of gong to a 15-volt direct-current generator. Where a generator is not available a storage battery can be used. The circuit was run to various points in the engine room and small receptacles installed, in which were placed low-voltage red lamps, so that if the engineer did not hear the gong he would see the lamps and know the gong was ringing. A diagram of the installation is shown in the illustration. This arrangement places all lamps and the gong in parallel but in series with the push-button, which must have good contacts to carry the necessary amperage at low voltage.

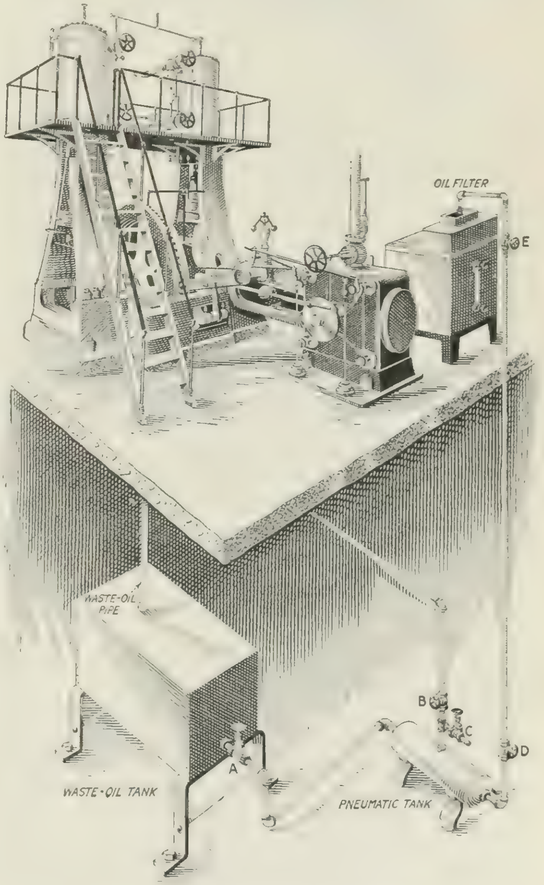
Thus, when the cupola button is pushed the gong rings and the lamps blink the signal, and even if the engineer is in a far corner of the engine room he can catch the signal without listening for the gong. If a battery is used for power supply, the best arrangement is a 4- or 5-ampere storage battery so connected to a direct-current generator that weekly charging is possible.

This system was installed to help an engineer who was hard of hearing and got into many disputes over the air signals, but his successor also pronounced the scheme "a good thing." H. S. RICH.

Hartford, Conn.

Oil Handled by Air Pressure

The illustration shows an easy and cleanly means of handling the otherwise waste oil from engines and other machines. It was installed by the writer and handles all the oil from four engines and two refrigerating machines at the plant. All the material used was found around the plant, the only outlay being for labor and most of that was "spare time."



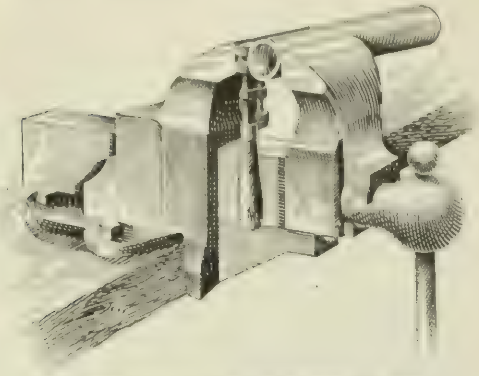
PIPING OF OIL-HANDLING SYSTEM

The oil is conducted by suitable drains to a galvanized-iron tank in the basement, from which it is drawn through the valve *A* into the pneumatic tank, which is a 15-gal. heating boiler. The valve *C* is left open to vent the air during the filling processes. After the pneumatic tank is filled, valves *A* and *C* are closed and *B* and *D* opened, air from the compressed-air system being admitted at *B*. By means of the valve *E* the operator regulates the flow of oil to suit the capacity of the filter. C. J. DOMVILLE.

Port Hawkesburg, N. S.

Holding Pipe in a Vise

A handy way of holding a pipe or other piece of round material in an ordinary bench vise is by the use of a common monkey wrench. The wrench when inserted in the vise and adjusted to fit the piece to be held will grip it with a force that will resist any turning effort while it is being worked upon. The method of applying the wrench is shown in the illustration.



HOW PIPE CAN BE HELD TIGHT IN VISE

Guantanamo, Cuba. W. W. **Parker.**

Value of Station Records

The most valuable records of power-plant operation that can be kept are the daily records of coal burned, steam evaporated and used and kilowatt-hours generated. These figures, properly recorded and analyzed, will show up the weak points in the operation of the equipment and suggest the remedies.

When the engineer in charge of the station knows that he burned 3 lb. of coal for every kilowatt-hour generated one month, and 3.5 lb. of coal for every kilowatt-hour generated the next month, he may be able to account for that difference in efficiency to his own satisfaction by saying that there must be a difference in the quality of coal burned or that the boilers needed cleaning. But the fact remains that there has been a whole month of performance that was not the best that could be expected of the equipment.

Suppose now that the engineer in question had been in a position to keep daily records of coal burned as well as the kilowatt-hours generated and had watched these figures day by day. He would then have detected the rising coal rate as soon as it appeared and would have been warned to look for the trouble. If there had been no change in the coal supply, it would be evident that the trouble was in the performance of the equipment and he would have to proceed by a process of elimination to hunt out the faulty spot.

Of course the first step would be to try to find out whether the trouble was in the boiler room or in the turbine room. For this the engineer would turn to his record of steam evaporated and see whether the pounds of steam per pound of coal had fallen off any. If not, it would be safe to infer that the trouble was not in the boiler room. If there were no flow meters on the boilers he would have to depend on the feed-water meter for the amount of steam evaporated.

Having traced the trouble to the turbine room, the next step would be to locate the faulty unit. This would be facilitated by having a flow meter on each generating unit. If he found no increased steam rates on the generating units he would have to hunt through the auxiliary equipment for the loss. Thus, the more carefully the engineer kept the records on the operation of his equipment the more surely and quickly he could locate the loss in efficiency.

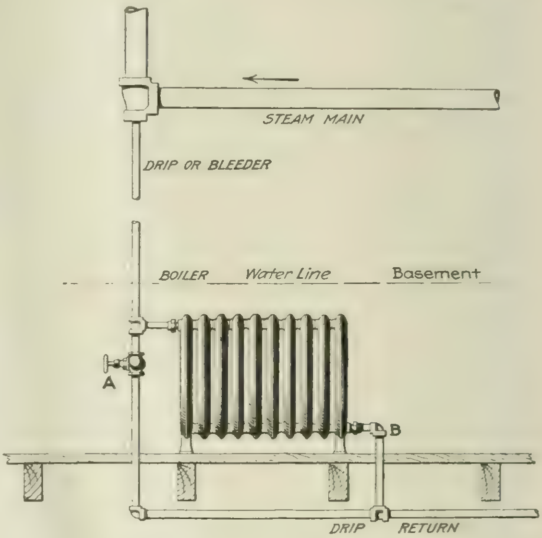
Now suppose that the steam evaporated per pound of coal burned had shown a substantial decrease. Then it would have been certain that the trouble was in the boiler room. We will assume that the engineer has had samples of coal tested from time to time and knows that he is burning as good a grade of coal as usual. Then he will have to decide that one or more of the boilers is at fault. But which one? Here, again, a flow meter on each unit will simplify the problem by pointing out which unit has fallen off in evaporation rate.

In every case when the faulty unit has been located, it can be cut out at once and put into good operating condition with a minimum of delay. If the facilities are available for testing samples of coal burned daily, complete records of the thermal efficiency of the plant may be kept. C. C. **Raitt.**

Dayton, Ohio.

Radiator Heated from Main Drip

On page 325 of the Mar. 4 issue of *Power*, W. T. Meinzer describes how to heat a radiator located below the vacuum return main. The accompanying sketch shows how some heat can be secured from a radiator located in a cellar or basement below the boiler water line on a low-pressure, gravity-return, steam-heating system. By closing the valve *A* all the water of condensation from the steam main will pass through the radiator. If a check valve is placed on the radiator outlet at *B*, any possible chance of a "come back" is prevented.



RADIATOR BELOW BOILER WATER LEVEL

If it should be necessary to have the radiator cold at times, this will occur when the valve *A* is opened.

Kingston, Ont., Canada. James E. **Noble.**

Inquiries of General Interest

Valve Cutting from Lack of Lubrication.—What effect would it have on the steam valves and valve seats of a tandem air compressor, with 7- and 14-in. compound steam cylinders, using the compressor by admitting live steam through a bypass to the low-pressure cylinder? J. C. R.

A bypass to the low-pressure cylinder is usually intended only for warming up and starting, and if lubrication is not provided during extensive use of the bypass for operating the compressor, the valves and valve seats are likely to become cut.

Slower Cooking in Trapped Steam-Jacketed Kettles—Why should the same amount of cooking in our steam-jacketed kettles require about twice as much time when the discharge of condensate is controlled by traps as when the kettles are supplied with steam of the same pressure and the condensate is discharged by an open bypass? P. E. N.

When the traps are used there is less active circulation of the steam and slower absorption of heat by the heating surfaces of the kettles, mainly on account of air pockets formed in the steam spaces of the kettles, which are more thoroughly swept out when the flow of steam is continuous.

Weight of Compressed Air—What is the weight of 24 cu.ft. of dry air at a temperature of 125 deg. F. under a pressure of 26 lb. per sq.in. gage? E. C.

At atmospheric pressure, or 14.696 lb. per sq.in. absolute, a pound of dry air at 32 deg. F., or an absolute temperature of $460 + 32 = 492$ deg., has a volume of 12.387 cu.ft.; and as the density is inversely as the absolute temperature and directly as the absolute pressure, the weight of 12 cu.ft. of air at the temperature of 125 deg. F., or $460 + 125 = 585$ deg. F., and pressure of 26 lb. per sq.in. gage, or $26 + 14.696 = 40.696$ lb. per sq.in. absolute, would be

$$\frac{492 \times 40.696 \times 24}{585 \times 14.696 \times 12.387} = 74 \text{ lb.}$$

Piston Clearance and Clearance Volume—What is meant by clearance of an engine? W. R. G.

The term clearance is used in two senses. It may refer to the distance the piston could be separately moved beyond its position at the end of the stroke before it would come in contact with the head of the cylinder, or the term may be used with reference to the volume of space in the end of the cylinder and connected passages, from the piston to the valves, when the piston is at the end of its stroke. To avoid confusion the former is called "piston clearance" and is always a lineal measurement, and the latter is termed simply "clearance" and the amount generally is quoted as a percentage of the volume swept through by one stroke of the piston.

Factor of Evaporation Generating Superheated Steam.—What is the factor of evaporation when, under actual conditions, a boiler generates steam at 200 lb. gage with 100 deg. superheat from feed water at 212 deg. F.; and how many pounds of water have to be evaporated per boiler horsepower? J. J. R.

An absolute pressure of 200 lb. gage would be equal to 215 lb. per sq.in. absolute, and, according to the steam tables, a pound of steam at that pressure, superheated 100 deg. F., contains 1259 B.t.u. above 32 deg. F., so that if the feed water temperature is 212 deg. F., each pound of feed water for conversion into steam of the stated pressure and quality must receive $1259 + 32 - 212 = 1079$ B.t.u. Unless otherwise provided, a combined boiler and superheater should be treated as one unit and the equivalent of the work done by the superheater should be included in the evaporative work of the boiler. Evaporation of a pound of water from and at 212 deg. F. requires 970.4 B.t.u., and therefore, under the actual conditions, the factor of evaporation would be $1079 \div 970.4 = 1.111$; and as a boiler horsepower is equivalent to the evaporation of 34.5 lb. of water from and at 212 deg. F. per hour, under the conditions stated a boiler horsepower would require evaporation of $34.5 \div 1.111 = 31.05$ lb. of water per hour.

Primary and Secondary of Transformers—Is the high-voltage winding of a potential transformer always considered the primary? If a transformer is designed to step 2300-volt alternating current down to 115, and it is connected to step 115-volt current up to 2300 volts, which winding will be the primary? M. A. B.

The winding of a transformer which is connected to the source of power is the primary, and the winding connected to the load is the secondary. When the transformer referred to in the question is connected to step from 2300 down to 115 volts, the 2300-volt winding is the primary. When it is connected to step from 115 up to 2300 volts, the 115-volt winding is the primary and the 2300-volt winding the secondary.

Effectiveness of Small Economizer.—To what temperature could water at 60 deg. F. be heated in its passage once in 12 minutes, through a pipe-coil economizer containing 200 lineal feet of 1¼-in. iron pipe placed in a boiler smoke flue in which the uptake gases have a temperature of 600 deg. F.? E. C. A.

There would be 87 sq.ft. of pipe surface for heating about 78 gallons of water per hour. The rate of heat transfer would depend on the arrangement of the pipe surface in the path of the flue gases, the volume of the heated gases and the manner in which they are swept over the pipe surfaces, and the freedom of the surfaces from soot and scale. If the coil is made in the form of a stack of pipes, placed in the smoke flue approximately at right angles to the direction of flow of the gases, and the pipe surfaces are kept as free of soot and scale as it is customary to maintain boiler-heating surface in good practice, and there is sufficient flue gases to retain a temperature of not less than 500 deg. F. after passing across the coil, it is estimated that the water could be heated to about 300 deg. F.

Current Taken by Induction Motor—How is the current taken by an induction motor calculated? I have a 25-hp. three-phase 60-cycle 220-volt induction motor and would like to know how to figure the full-load current. V. K. S.

The current per terminal taken by an induction motor usually can be found on the name-plate of the machine. Formulas that give values close enough for practical purposes are: For single-phase motors the full-load current per terminal is: amperes $= \frac{\text{horsepower} \times 1000}{\text{volts}}$; for 4-wire, two-phase motors, amperes per terminal $= \frac{\text{horsepower} \times 1000}{\text{volts} \times 2}$; for 3-wire operation the current in the outside wires is the same as for a 4-wire circuit, but the current in the center leg is equal to the outside-leg amperes times 1.414. For a three-phase motor the amperes per terminal $= \frac{\text{horsepower} \times 1000}{\text{volts} \times 1.732}$, or in your problem equals $\frac{25 \times 1000}{220 \times 1.732} = 65.6$ amperes.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

High Steam Pressures*

REPORTS of the Prime Movers Committee presented at the conventions held in 1916 and 1917 gave a brief comprehensive outline of the possible economies to be obtained by going to the so-called higher steam pressures, the principal difficulties to be encountered and a statement on this subject from some of the leading manufacturers of boilers and turbines. Since then, little actual progress has been made, chiefly because the thoughts and energy of everyone have been devoted to winning the war.

The project is by no means dead, and during the interval the Buffalo General Electric Co. has placed in service a plant designed to be operated at 275 lb. boiler pressure and 275 deg. superheat, giving a total temperature of 689 deg. F. The Public Service Co. of Northern Illinois has installed and is operating a plant with a boiler pressure of 315 lb., and 225 deg. F. superheat, giving a total temperature of 651 deg. F.; the British Thomson-Houston Co. has had in operation in its works at Rugby, England, a small boiler plant operated at about 350 lb. pressure and with such superheat that the total temperature ranges from 700 deg. F. to 750 deg. F. at the boiler.

While minor troubles have been encountered at all these installations, such as might be anticipated when the pressure and temperature of the steam system are increased, the committee is advised that in each instance the installation is considered generally satisfactory.

There have been practically no troubles with the boiler or turbines, due to the changed steam conditions. Flange joints in the steam piping lines and under the bonnets in the gate valves proved more troublesome to install and maintain. The small valves, gage-cocks and like apparatus, which usually are more troublesome to maintain than the larger apparatus, have required much more attention. Minute blow-holes in valve bodies, fittings, etc., which would not be expected to give trouble on lower pressures, have shown troublesome leaks on the higher pressures. These should be expected and are usually corrected as soon as there is sufficient demand on the manufacturers to justify developing apparatus for the new conditions.

These installations, however, are but a step in the direction that it is possible to go, and in analyzing these possibilities it is first necessary to see what are the limits and then the possibilities of approaching these limits. The first limit is undoubtedly the boiler. The Babcock & Wilcox Co. advises the committee that the statement submitted by the committee in the 1916 report covers the situation today and that it has nothing further to add at this time. The company states that the intervening war period has much interfered with its experimental work, and although these experiments have been continued they necessarily have been made under adverse conditions, and nothing further can be added at this time on the possibility of building boilers for pressures higher than 300 to 350 pounds.

While it may be possible to increase the boiler pressure to almost any desired point by changing design, there is today a definite limit to the maximum temperature which it is safe to use. That is fixed by the steels now in commercial use and appears to be between 600 and 700 deg. F. This is brought out by the following statement made by Charles L. Huston, vice president and works manager of the Lukens Steel Company:

> While we do not have records to indicate the service qualities of steel at temperatures higher than those at present in use, I believe I could say with a good deal of confidence that the use of soft carbon steel, say 50,000 lb. to 60,000 lb. tensile strength, would be thoroughly safe up to temperatures of, say, 600 deg. F. or under the critical temperature of steel, which varies little between soft and medium hard steels.
>
> I do not believe that the use of higher tensile-strength steel in standard carbon steels would be desirable, for the reason that as the critical point in steel, say about 700 deg. F., is approached the metal becomes less ductile and would be more likely to crack.
>
> In the above statement I am expressing my opinion simply in regard to standard carbon steels and not touching upon alloy steels, the behavior of which at these high temperatures I am not familiar with, nor do I know of any experiments of similar character that have been made in recent years on such steels.
>
> From the fact, however, that these old experiments (made by Dr. Huston and his father in 1876—"Journal," Franklin Institute, 1878) showed similar characteristics with chrome steel as compared with carbon steel I have been led to infer that the same conclusions might be applied generally to all classes of steel, viz. that when you get up into higher temperatures it is desirable to keep soft, ductile material.
>
> Many people regard a piece of steel as an absolutely homogeneous mass of metal, whereas all steels consist of a mixture of ferrite crystals with various metalloids, usually carbide of iron, phosphide of iron and sulphide of iron, interlarded between the ferrite crystals, the ferrite having the highest melting point in the combination and the different metalloids requiring different degrees of temperature to fuse them. The greater the variety of metalloids, introduced into the steel, the greater is the need of ascertaining the fusing point of these different metalloids, for the reason that when the steel is heated to a temperature where the weakest metalloid is either fused or its structure broken down by the heat, the strength or ductility of the whole mass is more or less impaired.
>
> Therefore, I should incline to think that unless very elaborate experiments have been made and service tests obtained from any theoretical alloy steel that might be thought advantageous to use it would be safer in the meantime to stick to soft steel of straight carbon quality, which carries the largest proportion of pure ferrite in its make-up.

The attitude of the Allis-Chalmers Co. on the turbine end is clearly explained in the following quotation from its letter:

> We would advise that our standard high-pressure condensing steam-turbine apparatus is designed for working steam pressure as high as 200 lb. gage for the smaller machine and 250 lb. gage for the larger ones. Therefore, for pressures of 300 lb. gage and above some special development would be involved in each case. We find that our standard line of apparatus is suitable for practically all of the inquiries we receive, and as pressures above 250 lb. gage would apply entirely to the larger units, the development to meet such pressures would not be excessive, as it is our practice to blade the larger machines for as near to actual operating conditions as our manufacturing standards will permit.
>
> For temperatures above about 500 deg. F., we use a partial cast steel up to about 650 deg. F., above which temperature we have steel cylinder construction which we feel is suitable for maximum temperatures.
>
> We do not find much tendency in this country to go above normal operating temperature of about 600 deg. F. except in very extreme cases for large units and, with this temperature, steam pressures of 300 lb. gage or 350 lb. gage do not offer any difficulties or involve any considerable special development expenses.

The General Electric Co. makes the following statement:

> Turbines suitable for higher pressures can without question be produced without involving us in any complications by the time that boilers can be furnished for said purpose. It would appear that this matter is essentially a boiler problem. We can supply the turbines for you, if you can obtain the boilers.

A full discussion of the possibilities appeared in the paper by Eskil Berg on "Advantages of Higher Pressure and Superheat as Affecting Steam Plant Efficiency," which was published in the *General Electric Review* of March, 1918.

The position of the Westinghouse Electric and Manufacturing Co. is clearly stated in the following quotations from its letters:

> We look with favor upon the gradual upward tendency in steam pressures, but with moderation on the total temperature. In other words, speaking from the standpoint of the turbine alone, if the central station were ready with its piping and fittings and with its operating knowledge to use pressures of 300 lb. and above, we would say that we are ready with the turbine, and we would approve of the step being taken. With our present knowledge of power-plant efficiencies it seems as though any future

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*From Report of Prime Movers Committee and Discussion, National Electric Light Association's Convention, 1919.

> material improvement must lie in that direction. We think your committee can well assume that the turbine is not or should not be one of your problems. We think perhaps that the practice will have to start with the large central stations. It will be a manufacturing handicap if we have to build both high-pressure and moderate-pressure machines. However, between the operators and the manufacturers it should always be possible to find feasible methods of doing anything that is sound and economically desirable.
>
> We wish to state that the effect of the higher steam pressure is to add materially to the cycle. The efficiency of the turbine will become less because of the smaller volume and greater density of the steam at the high-pressure end, and because of the greater quantity of moisture at the exhaust end.
>
> To date no turbines have been built adaptable for pressures beyond 300 lb. Some few are being built by this company for this pressure. For pressures higher than 300 lb. newly designed turbines will be required. There will not necessarily be any change in type, but merely additional elements to handle economically the added pressure range. Of course steam chests and controlling valves represent some difficulty in design, but these seem to be by no means insurmountable. In this connection it should be noted that the valves will not be materially less in size because of the smaller volume of the steam. If the steam velocity in the valves and piping were made inversely proportional to the density, the valves and piping would remain the same size.
>
> We think the question as to what extent this company is prepared to go in furnishing turbines built for steam pressures higher than 300 lb. is as much a commercial consideration as one of engineering, considering the development costs involved. There is no doubt that turbines can be built for these higher pressures, and there will be gains in economy due to this, such as above outlined. I would say that if we attempt to design turbines for these higher pressures, we would prefer this to be brought about by an increase of pressure without material increase of temperature; that is to say, we would prefer a reduction in the superheat; for instance, 500 lb. pressure with a superheat that would give a total temperature not to exceed 650 deg., that is, about 170 deg. superheat.

Apparently the manufacturers of steam turbines favor the movement toward higher pressures and are prepared to meet it, while manufacturers of boilers require time for further investigation and development work before they go much above the existing limit, which is around 350 lb. The economizer situation is less satisfactory; the limit of pressure appears to have been reached with the standard cast-iron economizer now in use. To go beyond this point would require either an entirely new type of economizer, or an installation of the present type operated at a pressure much below that of the boiler, which would require running boiler-feed pumps in series.

Little attention appears to have been given to adapting to higher steam pressures the various steam auxiliaries required in the installation. While these units are comparatively small in size, they are numerous and require proportionately more attention from the operating force than the larger units. It is just as important to avoid trouble with them as it is with the main prime mover. Your committee is also unable to learn that manufacturers of valves, fittings and other steam appurtenances of the power plant have given any special thought toward adapting their apparatus for pressures much above those now common. It would, therefore, seem that there is much further development work to be done before a successful installation of pressures above those now in common use can readily be made. Probably the initiative will have to come from the users, and when there is sufficient demand for improvements in the existing construction, the manufacturers will respond as readily and as successfully as they have in the past.

Another factor which has a bearing on this project is the position that the boiler-insurance companies may take. Statements have been obtained from some of the leading companies.

One company states:

> We are pleased to advise you that the pressure for which the safety valves on steam boilers are set has no bearing on the rates charged for steam-boiler insurance. Steam-boiler insuring companies require that steam boilers be so constructed and operated that they shall have a computed factor of safety of at least five on the pressure carried. Some companies will not reject a risk unless the factor of safety is less than four; but I believe no boiler-insuring company will carry a boiler risk when the computed safety is less than four. You probably know that the Boiler Code of the American Society of Mechanical Engineers requires that all new boilers be constructed so as to have a factor of safety of at least five.
>
> With boiler-insuring companies a steam boiler is either safe or unsafe. If it is unsafe, there is no amount of premium that any insurance company will accept to carry the risk. If it is safe, then the premium is the same whether the safety valve be set for 225 or 450 lb. per sq.in. providing there is a computed factor of safety of five.

Another company writes:

> We wish to advise you that the rate of insurance on a boiler carrying 300 lb. pressure or more would depend upon the amount of the liability, or in other words the amount required by the assured. Further, we would advise that the rates for steam-boiler insurance are standardized. All companies are required to give the same amount of premium for the same amount of insurance; the amount required can be readily determined on application for a specified amount of coverage.

It would appear from the above that the companies insuring boilers would not decline to write insurance on a boiler operated at any pressure within the limits herein discussed, provided said boiler had a proper factor of safety.

If steam plants are to increase their pressure materially, the wise procedure would be to do so gradually, or in steps of moderate increases each. By this method, troubles and losses would be minimized and the experience with one installation would help solve the problems for the next increase.

The coal consumption of this country is increasing at a rapid rate, the cost of fuel is steadily rising and the total supply of good steam coal has a definite limit; therefore, it is the duty of the engineer to consider all practical methods to conserve this source of power and to utilize it in the most economical manner. Higher steam pressure will be helpful; it should be carefully studied and used wherever the conditions will permit.

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DISCUSSION

R. H. Rice, Turbine Department, General Electric Co., Lynn, Mass.: Higher steam pressures for turbines is one of the obvious, and I believe practical, methods of extending the range of available energy derived from fuel burned under boilers, and thereby extending the range or output from that fuel. In other words, increased output without increase of fuel.

There are several methods by which we can increase the available energy: One is by increasing the steam pressure; another is by increasing the vacuum at the turbine wheels, and another is in extracting more heat from the flue gases in their passage to the atmosphere. I think in considering this question of increased steam pressure we should consider the problem from all these standpoints. I would make this suggestion to the committee, that instead of considering the subject from the standpoint of Rankine-cycle efficiency, it be considered from the standpoint of thermal efficiency. In other words, the percentage of power on the switchboard developed from the available energy in the coal. Power plants of the best type give 18 or 19 per cent. thermal efficiency. By increasing that, by taking out all the heat from the flues gases which it is possible to take out, brings their temperature down to 125 or 150 deg. F., whereas now they are commonly at 400 or 500 deg. By using all possible means for securing highest vacuum at the turbine wheels. This means a suitable condenser bolted in horizontal or vertical position to the turbine shell, and with the largest opening it is possible to provide between the turbine shell and the condenser. With these we should be able, in plants of very reasonable size, to secure 25 per cent. thermal efficiency, and in the largest plants 28 or 29 per cent. That gain is worth striving for.

Extract More Heat from Flue Gases

Relative to extracting more heat from the gas, this might be done by extending the feed water, or by a regenerative action, by first taking the air for the boiler furnaces through pipes connected with the flues, and extracting the heat from the gases going to the atmosphere.

As to the possibility of using 500 or 600 lb. steam pressure, I do not think that we now have enough knowledge to warrant building a plant for that pressure. But I am satisfied it would be practical at this time to construct a plant of 2000 or 3000 kw. capacity, which would operate safely with 500 or 600 lb. pressure. In the evolution of higher steam pressures we should go the limit, especially if we are building a plant having as small units as above; so that we may try out at one time all the different problems which will arise from such considerable increase in boiler pressure. Results obtained with steam at 300 lb. or 350 lb. pressure are most pleasing. There seems to be no reason why, with materials and with knowledge of designs, we should not go to those pressures directly.

I am of opinion that such pressures would result in a change in the power stations. The steam turbines should be located as near to the boilers as possible, to reduce the high-pressure losses. The construction of those high-pressure mains, pipes and valves involves some problems which are not impossible of solution.

Steel the Limiting Factor

A. L. Meyer, Lukens Steel Co., Coatesville, Penn.: As far as I am able to read this report, it seems that all the manufacturers who make apparatus to give higher steam pressure point to the boiler as the object which they want to make a certainty. So far we have not been able to find any actual tests which I have read in this report, where the boiler pressure has gone to a high temperature of 600 or 700 deg. F. But we feel certain that by the use of the present low-carbon steels, which give a tensile strength of 50,000 to 60,000 lb., the boilermaker will be able to produce a boiler that will stand these pressures. In 1880 Dr. Huston performed some experiments which showed that up to 700 deg. F. the tensile strength was equal to 100 per cent. or better than the original. When the temperature got beyond 700 deg. the curve dropped decidedly. Since that time J. E. Howard, of the Bureau of Standards, Mr. Coleman, from Oberhurst, and the Shelby Co. have performed similar experiments and corroborated Dr. Huston's experiments.

I. E. Moultrop, Edison Electric Illuminating Co., Boston: Someone must work out this problem. There are some limitations in the design and in the material used in the boiler of today. The boiler builders do not care to go beyond 350 lb. today, as far as I understand, owing to the working out of the design and the limitations imposed upon them by commercial steel. Someone should try higher pressures in a small way and go the limit. It is an undertaking none of the utility companies care to take. I think the way to do this is to get the manufacturers to coöperate on the subject—the principal turbine manufacturers, and the auxiliary manufacturers, and boiler manufacturers, should combine, put up a small experimental plant somewhere and actually try higher steam pressures. With the rising prices of coal and labor we must improve the economy of our power stations.

O. F. Junggren, Engineer, Turbine Department, General Electric Co., Schenectady, N. Y.: Engineers are continuously reaching out for improvements, and as long as we use steam as a medium we must ascertain how we can utilize steam to the best advantage. We can only go into the upper range, as the lower range has already been reached and depends upon condensing water. Another way is to superheat steam to a temperature as high as feasible, then run it through the turbine, and finally condense it. But that is not the vital thing. You should increase the pressure and reduce the superheat, as the higher the pressure the greater the improvement, because relatively less steam is transformed to water in the condenser. If we could get rid of the condenser, we would have the ideal condition. We do not know how to do that; but every reduction of one per cent. of quality of steam sent to the condenser is clear gain.

To manufacturers of boilers and of auxiliaries, pressures of 600 and 800 lb. are feasible, and I do not know why that is not the proper way to get at it. The success of the electrical industry has been that the leading men in it have taken steps forward continuously to reach higher efficiency. Of course there will be boiler problems, and the turbine will probably look much different from what it does today operating under pressures of about 200 to 300 lb.

Bureau of Research of the American Society of Heating and Ventilating Engineers

The function of the Bureau of Research is the determination and dissemination of engineering knowledge pertaining to the profession of heating and ventilating and to the equipment and apparatus utilized by the profession at large; it will be run in coöperation with the Bureau of Mines.

The Committee on Research of this society announces the success of its preliminary plans for the establishment of the contemplated Research Bureau and the selection of a director, with the prospect that actual investigations will begin about the middle of the year. The drive for solicitation of funds for the financing of the Bureau which was being prosecuted so vigorously at the time of the annual meeting in January, has been so successful, and the support given not only by other associated organizations, but also by the Government, has been so generous that the success of the undertaking is assured. The committee has been able to secure the services of Prof. John R. Allen as Director of the Bureau. Professor Allen, who was a past-president of the society, is well known for his work in research in heat engineering at both the University of Michigan, where he served many years as professor of mechanical engineering. and of late at the University of Minnesota, where he is dean of engineering and architecture. With Professor Allen's leadership and the cordial interest and support of the United States Bureau of Mines in placing a portion of its magnificent laboratories at Pittsburgh, Penn., at the disposal of the Bureau, it is certain that results will be obtained which will not only prove helpful and constructive in this field of engineering, but also unmistakably demonstrate the ideal relation of the national engineering society to the public in affairs of national economic importance Professor Allen's offices will be at Pittsburgh.

In the course of a paper read before the Liverpool Engineering Society, says *The Engineer*, B. Rathmell recommended the use of single-, rather than double-acting, compressors in carbon dioxide refrigerating machinery. Such compressors, he said, properly designed, minimize most of the defects commonly found. The compressor can be filled with gas at the full suction pressure; clearance spaces are practically eliminated; large valves with very small lifts can be used; the flow of gas may follow one direction, allowing for the lagging of the cold suction parts and the water-jacketing of the hot discharge parts; higher speeds of revolution can be used than with double-acting compressors; and the piston-rod glands may be kept under the lowest and constant temperature.

Interpretations of the Boiler Code

The following interpretations by the Boiler Code Committee of the American Society of Mechanical Engineers are released for publication:

CASE No. 215

Inquiry: Is it permissible under the requirements of Par. 257 of the Boiler Code to remove the calking edges of plates, butt straps and heads by burning them off by the oxyacetylene process instead of planing, milling or chipping?

Par. 257. *Calking.* The calking edges of plates, butt straps and heads shall be beveled to an angle not sharper than 70 deg. to the plane of the plate, and as near thereto as practicable. Every portion of the sheared surfaces of the calking edges of plates, butt straps and heads shall be planed, milled or chipped to a depth of not less than $\frac{1}{8}$ in. Calking shall be done with a round-nosed tool.

Reply: Removing the calking edges of plates, butt straps and heads by the oxyacetylene burning process will not be in compliance with the intent of the Boiler Code in Par. 257.

CASE No. 216

Inquiry: An interpretation is requested of the relation between Section *a* of Par. 275 of the Boiler Code and Sections *b* and *c*. Section *a* would appear to allow 12 per cent. more relieving capacity to a valve than either Section *b* or *c*.

Par. 275. Safety-valve capacity may be checked in any one of the three following ways, and if found insufficient, additional capacity shall be provided:

a. By making an accumulation test; that is, by shutting off all other steam-discharge outlets from the boiler and forcing the fires to the maximum. The safety-valve equipment shall be sufficient to prevent an excess pressure beyond that specified in Par. 270. [See under Case 226.]

b. By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel.

c. By determining the maximum evaporative capacity by measuring the feed water. The sum of the safety-valve capacities marked on the valves shall be equal to or greater than the maximum evaporative capacity of the boiler.

Reply: The committee purposely limited the requirements for rating of safety valves to 3 per cent. increase in pressure over that at which the valve is set to blow; that is, one-half the maximum allowable increase of 6 per cent., so that a margin of safety represented by the difference between 6 per cent. and 3 per cent. would be provided.

CASE No. 218

Inquiry: For material to be used as headers and manifolds of superheaters, does that of openhearth extra-heavy lap-welded steel pipe meet the requirements of Par. 11 and the material specifications of the Boiler Code? It is found that the average analyses of such lap-welded pipe appear to meet the physical and chemical requirements of either the boiler-plate steel specifications, or the specifications for steel castings of Class-B Grade, although they do not conform fully to either one separately.

Par. 9. Cross-pipes connecting the steam and water drums of water-tube boilers, headers, cross-boxes and all pressure parts of the boiler proper over 2-in. pipe size, or equivalent cross-sectional area, shall be of wrought steel, or cast steel of Class-B grade, as designated in the Specifications for Steel Castings, when the maximum allowable working pressure exceeds 160 lb. per sq.in. Malleable iron may be also used when the maximum allowable working pressure does not exceed 200 lb. per sq.in., provided the form and size of the internal cross-section perpendicular to the longest dimension of the box is such that it will fall within a 7 in. by 7 in. rectangle.

Par. 11. Pressure parts of superheaters, separately fired or attached to stationary boilers, unless of the locomotive type, shall be of wrought steel, or cast steel of Class-B grade, as designated in the Specifications for Steel Castings.

Reply: It is the opinion of the committee that, under the requirements of Pars. 9 and 11, headers and manifolds of superheaters must be constructed from material which, in its initial form of plate or skelp, conforms to one or the other of the specifications given in the Boiler Code for wrought steel; or they may be constructed of cast steel of the Class-B Grade.

CASE No. 219

Inquiry a: Is it the intention under Par. 184*c* of the Boiler Code to deduct the rivet holes when figuring "the full strength of the plate corresponding to the thickness at the joint?"

Par. 184c. In the portion of circumferential joints of horizontal return-tubular boilers, exposed to the products of combustion, the shearing strength of the rivets shall be not less than 50 per cent. of the full strength of the plate corresponding to the thickness at the joint.

Reply: It is not the intention under Par. 184*c* of the Boiler Code to deduct the rivet holes when figuring "the full strength of the plate corresponding to the thickness at the joint."

Inquiry b: An interpretation is requested of Par. 201, as regards the constant in the formula for stay-bolts. This paragraph requires that "the spacing of the rivets over the supported surface shall be in conformity with that specified for stay-bolts," but we fail to find a constant which seems to fit the case.

Par. 201. *Structural Reinforcements.* When channel irons or other members are securely riveted to the boiler heads for attaching through stays, the transverse stress on such members shall not exceed 12,500 lb. per sq.in. In computing the stress the section modulus of the member shall be used without addition for the strength of the plate. The spacing of the rivets over the supported surface shall be in conformity with that specified for stay-bolts.

Reply: The constant *C* used in the formula for rivets shall be that given in Par. 199 for stays screwed through the plates with the ends riveted over. This means that *C* shall be 112 or 120, depending on the thickness of the plate.

Par. 199. $C = 112$ for stays screwed through plates not over $\frac{7}{16}$-in. thick with ends riveted over.
$C = 120$ for stays screwed through plates over $\frac{7}{16}$-in. thick with ends riveted over.

CASE No. 221

Inquiry: Is it necessary under the requirements of the Boiler Code that small vertical tubular boilers such as are used for clothes-pressing, vulcanizing and laundry service, shall be fitted with gage-cocks when a water-gage glass is attached?

Reply: It is the opinion of the committee that a boiler of this type that is operated with a fixed water level should be fitted with both water gage-glass and gage-cocks; or two gage-glasses, as indicated in Par. 294.

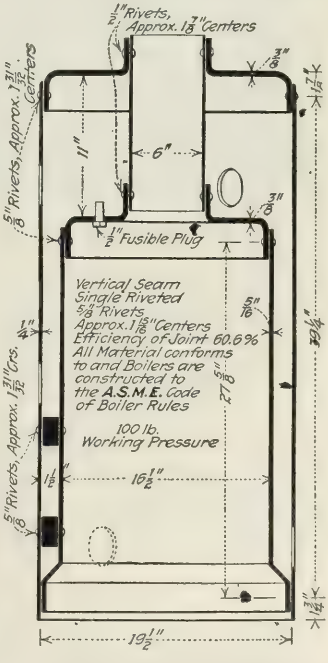
Par. 294. Each boiler shall have three or more gage-cocks, located within the range of the visible length of the water glass, except when such boiler has two water glasses with independent connections to the boiler and located on the same horizontal line and not less than 2 ft. apart.

CASE No. 222

Inquiry: What is the application of the limitation of length of stay-bolts given in Par. 200 of the Boiler Code, that must be drilled with telltale holes in their outside ends? Does this length of stay-bolt apply to inside distance between plates stayed or to the outside length of the bolt over all?

Par. 200. *Stay-Bolts.* The ends of screwed stay-bolts shall be riveted over or upset by equivalent process. The outside ends of solid stay-bolts, 8 in. and less in length, shall be drilled with a hole at least $\frac{3}{16}$ in. diameter to a depth extending at least $\frac{1}{2}$ in. beyond the inside of the plates or hollow stay-bolts may be used. On boilers having a grate area not exceeding 15 sq.ft., or the equivalent in gas- or oil-fired boilers, the drilling of stay-bolts is optional. Solid stay-bolts over 8 in. long, and flexible stay-bolts of either the jointed or ball-and-socket type, need not be drilled. Stay-bolts used in water-legs of water tube boilers shall be hollow and drilled at both ends, irrespective of their length.

Reply: Par. 200 of the Code specifies that "stay-bolts used in water-legs of water-tube boilers shall be hollow or drilled at both ends irrespective of their length." Par. 220*d* specifies that "the length of a stay between supports shall be measured from the inner faces of the stayed plates."



SINGLE-FLUE BOILER

CASE NO. 223

Inquiry: Is it necessary under the requirements of the Boiler Code to provide staying in a single-flue boiler 19½ in. in diameter by 43 in. high having a 16½-in. furnace, crown sheet of which is connected to the top head of the boiler by a 6-in. flue?

Reply: Inasmuch as the diameter of the furnace is less than 18 in., it is evident that under the requirements of Par. 239 the furnace will not require staying. There remains therefore only the crown sheet, top head of the boiler and the flue to be considered. Par. 203*d* or the latter part of Par. 216 are applicable to the crown sheet or the top head if formed of flat sheets. If, on the other hand, the crown sheet and top head are dished the maximum allowable working pressure is calculated from Par. 195. Par. 241 applies to the flue.

[In order that the reply may be intelligible the inquiry should have stated that the thickness of the furnace is $\frac{5}{16}$, its height 27⅝ and the pressure 100 lb. A reproduction of the blueprint accompanying the inquiry is reproduced herewith.—Editor.]

> Par. 239 specifies that unstayed furnaces more than 12 in. in diameter when riveted, of seamless construction or when lap welded by the forging process shall have walls not less than $\frac{5}{16}$ in. thick. The maximum allowable working pressure for such furnaces, from 12 to 18 in. diameter inclusive, of a length not more than 4½ diameters and not more than 120 times the thickness of the plate is determined as follows:
>
> $$P = \frac{51.5}{D}[(18.75 \times T) - (1.03 \times L)]$$
>
> where
>
> P = Maximum allowable working pressure in lb. per sq.in.;
> D = Outside diameter of furnace in inches;
> L = Total length of furnace between centers of head rivet seams (not length of a section) in inches;
> T = Thickness of furnace walls in sixteenths of an inch.

This gives an allowable pressure for the unstayed furnace in excess of the required 100 lb.

CASE NO. 224

Inquiry: Is it necessary that firebox steel of lower tensile strength than specified in Par. 28*a*, the use of which is sanctioned in Par. 28*c*, shall have a minimum carbon limit of 0.12 per cent. as specified for firebox steel in Par. 25?

> Par. 25. *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

		FLANGE	FIREBOX
Carbon			Plates ¾ in. thick and under. 0.12—0.25 per cent Plates over ¾ in. thick....0.12—0.30 per cent
Manganese		0.30—0.60 per cent	0.30—0.50 per cent
Phosphorus	Acid	Not over 0.05 per cent	Not over 0.04 per cent
	Basic	Not over 0.04 per cent	Not over 0.035 per cent
Sulphur		Not over 0.05 per cent	Not over 0.04 per cent

> Par. 28a. *Tension Tests.* The material shall conform to the following requirements as to tensile properties:

	FLANGE	FIREBOX
Tensile strength, lb. per sq. in.	55,000—65,000	55,000—65,000
Yield point, min., lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 8-in., min., per cent (See Par. 29)	$\frac{1,500,000}{\text{Tens. str.}}$	$\frac{1,500,000}{\text{Tens. str.}}$

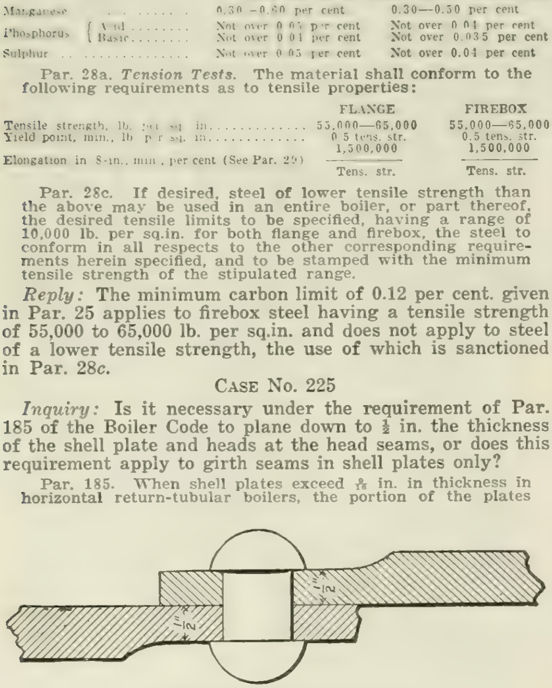
> Par. 28c. If desired, steel of lower tensile strength than the above may be used in an entire boiler, or part thereof, the desired tensile limits to be specified, having a range of 10,000 lb. per sq.in. for both flange and firebox, the steel to conform in all respects to the other corresponding requirements herein specified, and to be stamped with the minimum tensile strength of the stipulated range.

Reply: The minimum carbon limit of 0.12 per cent. given in Par. 25 applies to firebox steel having a tensile strength of 55,000 to 65,000 lb. per sq.in. and does not apply to steel of a lower tensile strength, the use of which is sanctioned in Par. 28*c*.

CASE NO. 225

Inquiry: Is it necessary under the requirement of Par. 185 of the Boiler Code to plane down to ½ in. the thickness of the shell plate and heads at the head seams, or does this requirement apply to girth seams in shell plates only?

> Par. 185. When shell plates exceed $\frac{9}{16}$ in. in thickness in horizontal return-tubular boilers, the portion of the plates forming the laps of the circumferential joints, where exposed to the fire or products of combustion, shall be planed or milled down as shown in the figure, to ½ in. thickness, provided the requirements in Par. 184 are complied with.



PLATES WITH EDGES PLANED

> The requirements of Par. 184 are that the strength of the circumferential joint shall be at least 50 per cent of that of the longitudinal joint in the case of heads not stayed by tubes, or 35 per cent if one-half or more of the load which would be caused by the pressure acting on an unstayed solid head is relieved by the effect of tubes or through stays; also that in the portion of the circumferential joint exposed to the fire or to the products of combustion the shearing strength of the rivets shall not be less than 50 per cent of the full strength of the plate.

Reply: It is the intent of the Code that Par. 185 shall apply to the plates at all circumferential joints on the shell of a horizontal return-tubular boiler where exposed to the fire or products of combustion. It therefore applies to a joint between the shell and the head where the joint in the shell is exposed to the products of combustion, in which case the plate is reduced in thickness if over $\frac{9}{16}$ in. in thickness, but the flange of the head is not so reduced.

CASE NO. 226

Inquiry: Is not the basis of determination of the relieving capacity of pop safety valves given in Par. 274 of the new edition of the Boiler Code a misprint? The bases of 6 lb., 5 lb. and 3 lb. of steam per hour per sq.ft. of boiler-heating surface for the different types of boilers do not seem to be in line with the other data given in the Boiler Code and not in line with good practice.

> Par. 274. The total relieving capacity of the safety valve or valves required on a boiler shall be not less than that determined on the basis of 6 lb. of steam per hour per sq.ft. of boiler-heating surface for water-tube boilers. For all other types of power boilers the total relieving capacity shall be not less than that determined on the basis of 5 lb. of steam per hour per sq.ft. of boiler-heating surface for boilers with maximum allowable working pressures above 100 lb., and on the basis of 3 lb. of steam per hour per sq.ft. of boiler-heating surface for boilers with maximum allowable working pressures at or below 100 lb. per sq.in.

Reply: The decision to base the required minimum capacity of safety valves on heating surface was made by the committee as a result of investigation of general average of operating duty for boilers in practice, it having been found that water-tube boilers rarely exceed a condition of forcing which will evaporate more than 6 lb. of steam per hour per sq.ft. of boiler-heating surface, whereas 5 lb. per hour seems to be the limit for high-pressure boilers of any other type; similarly practice with boilers operated at pressures of 100 lb. and under indicated that 3 lb. of steam per hour was a reasonably high figure. These relieving rates were therefore adopted; the provision of Par. 270 limiting the rise of pressure to 6 per cent. above the maximum allowable working pressure being ample for protection against any boiler emergency, as in case the evaporation is over the figure specified, additional safety-valve capacity must be added to meet this requirement.

> Par. 270. The safety-valve capacity for each boiler shall be such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 per cent. above the maximum allowable working pressure, or more than 6 per cent. above the highest pressure to which any valve is set.

CASE NO. 227

Inquiry a: Is Par. 12 of the Boiler Code intended to prohibit the use of cast iron on boiler nozzles, flanges and supporting lugs for any temperature or pressure? And does the rule permit the use of cast iron on superheater mountings for temperatures of less than 450 deg.?

> Par. 12. Cast iron shall not be used for nozzles or flanges attached directly to the boiler for any pressure or temperature, nor for boiler and super-heater mountings such as connecting pipes, fittings, valves and their bonnets, for steam temperatures of over 450 deg. F.

Reply: Par. 12 is not intended to prohibit the use of cast iron for supporting lugs or for boiler nozzles or flanges, provided such nozzles or flanges are not attached directly to the boiler or used for temperatures in excess of 450 deg. F.

Inquiry b: How far from the boiler are the Rules of the Boiler Code intended to apply? That is, do they cover beyond the second stop valve and do they extend indefinitely along the header and steam pipe?

Reply: The rules are intended to apply to the boiler structure only as far as and including the nozzles or flanges attached directly to the boiler and to the various accessories and appliances as specified. In Par. 305 of the Code, provisions are made to allow for expansion and contraction of steam mains and for the use of steam reservoirs on the steam mains in case there are pulsations of the steam currents that might cause vibration of the boiler shell plates. This paragraph is included for the protection of the boiler and is not intended to have a bearing on the general subject of design of steam mains.

> Par. 305. *Steam Mains.* Provisions shall be made for the expansion and contraction of steam mains connected to boilers, by providing substantial anchorage at suitable points, so that there shall be no undue strain transmitted to the boiler. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration of the boiler shell plates.

Engineering Council Notes

Contributed by M. O. Leighton, Chairman
National Service Committee

Engineers who were enrolled in the Reserve Corps at the beginning of the war will be interested in the circumstances related below. How many engineers had a similar experience? All who did are urged to send a detailed statement to the National Service Committee.

The following letter was addressed to the American Society of Civil Engineers by one of its associate-members resident in the Philippines, and finally came to the Washington office of Engineering Council:

> The American Society of Civil Engineers,
> Dear Sirs:
>
> As you are doubtless aware, the American Society of Civil Engineers during the war played a very considerable part in obtaining the services of engineers for the Army. Literature descriptive of the Engineer Officers' Reserve Corps was circulated throughout our membership and the society's appeal for men was probably responsible for a very large number of volunteers. In view of this fact, I am taking the liberty of advising you of certain instances in which the War Department through the Chief of Engineers seems to have violated the agreement under which the engineer officers were induced to offer their services.
>
> Among other things, we were informed that reserve corps officers when ordered to active duty would receive the pay and allowance that officers ordinarily do when changing stations. Any number of western engineers, several of them located in Alaska, applied for commissions in the first engineer reserve corps. After their applications had gone forward the reserve corps was abolished by the War Department. Without receiving any information to this effect these men were telegraphed offers of commissions in the Engineers, U. S. A. They were accepted and ordered to Camp A. A. Humphreys, Va., for duty as students. Upon their arrival there they were informed that they would receive no travel allowances at all. The seven cents a mile that they expected was not due them because they had accepted commissions in the regular army, not in the reserve corps. This was the first intimation that they had as to their new status. Most of the men, particularly those from Alaska, had been to a very considerable expense in traveling, as much as $350 in some cases.
>
> Another instance, one which covers my own case, occurred as follows: Some twenty-five or thirty of us entered the service in the Philippine Islands. We were discharged in the States, most of us in the eastern part. Our discharges came just too late to catch the December transport for the Philippines, so we were forced to wait for the January boat which arrives in Manila about February 15. We were thus over two months without pay, our army pay having stopped on the date of our discharge and our pay as civilians not beginning until our arrival in the Philippines. Anticipating these conditions, some of the men requested that they be ordered to the Philippines and discharged there or that they be returned to the inactive list in the reserve corps so that they could return to their homes with pay. Both of these requests were refused and the men discharged along with the rest.

On May 1 a letter was addressed to the Secretary of War in which the above communication was quoted with a request as follows:

> Will you be good enough to inform Engineering Council through the undersigned whether the facts as related in the letter above quoted are interpreted by the War Department in the same way as by Mr. ——— and whether there is an official intention to present the facts to Congress for the purpose of securing authority to reimburse discharged engineer officers of the Army whose experiences were similar to the above.

Up to May 24 no response had been received from the War Department, but we have hopes. While the author of the above letter recites an unfortunate train of circumstances, which seemingly reflects discredit on someone, judgment should be tempered with consideration.

Charles Edwin Knox

Charles E. Knox, one of New York's leading consulting electrical engineers, died at the age of 47 years, Sunday evening at St. Luke's Hospital, New York City, after a short illness of blood poisoning. Mr. Knox was born Sept. 17, 1871, at Atlanta, Ga. He came to New York City at an early age, attended New York City College, and the School of Mines at Columbia University, graduating as an electrical engineer in 1892. After graduating he was employed, in research work, in the laboratories of Queen & Co., Philadelphia, Penn. In 1893 Mr. Knox took the "Expert's Course" of the General Electric Co., at Lynn, Mass., and at the end of the year entered the employ of C. O. Mailloux as engineering assistant in the general practice of consulting engineering. From 1907 to 1913 he practiced as consulting engineer under the firm name of C. O. Mailloux & C. E. Knox, and since May, 1913, has practiced consulting engineering under his own name at 101 Park Ave., New York City.

CHARLES EDWIN KNOX

Mr. Knox has always been greatly interested in laboratory, mechanical and electrical work and when the School of Mines at Columbia University opened their course of electrical engineering in 1889 he made application and was admitted in 1890.

The particular branch of engineering practice to which his office is devoted is the designing of electric-light and power equipments for industrial plants, office buildings, hotels, factories and hospitals, department stores, etc., and elevator installations of all kinds. Some of the more important building installations, in New York City, on which he has acted as consulting engineer on the elevator and electrical equipment include the Wolworth, Municipal, Equitable, Metropolitan Life, Pennsylvania and Commodore Hotels, Columbia University Buildings,and Metropolitan Museum of Fine Arts.

In all Mr. Knox has been consulting electrical engineer on several hundred buildings in various parts of this country. He was considered an elevator expert of the highest standing, the height of the Equitable Building being determined by his report made to the owners on the estimated elevator traffic of that building Among his many war activities he was consulting engineer on the elevator installation in the U. S. Army Base Buildings in Brooklyn and Boston, the Brooklyn building having an installation of 90 elevators.

Mr. Knox was a member of many societies and clubs among which are: Fellow in the American Institute of Electrical Engineers, member of the New York Electrical Society, Institute of Consulting Engineers, Engineers' Club of New York, Columbia University Club and Columbia University School of Mines Alumni Association.

A. S. M. E. Spring Meeting

The American Society of Mechanical Engineers will hold its spring meeting in Detroit, Mich., June 6-19, with headquarters at the Hotel Statler. Monday forenoon will be occupied by registration of members and visitors, council and business meetings, etc. In the evening Mayor James Couzens will make an address of welcome. On Tuesday forenoon following the professional session will be the research session under the auspices of the Research Committee. The papers to be presented at this session are as follows: "The Present Condition of Research in the United States," by Arthur M. Greene, Jr.; "Research Work on Malleable Iron," by Enrique Touceda; "Reports of Sub-Committees on Flow Meters, Bearing Metals and Lubrication"; "The Organization and Conduct of an Industrial Laboratory," by A. D. Little and H. E. Howe. The Industrial Relations sessions will be held in the afternoon, at which the following papers will be presented: "Industrial Personnel Relations," by Arthur M. Young (contributed by the Chicago Section); "The Status of Industrial Relations," by L. P. Alford; "Certain Aspects of the Management Problem," by Magnus W. Alexander. Simultaneous sessions will be held on Wednesday. At the Mid-West Sections session the following papers will be presented: "Central Station Heating in Detroit," by J. H. Walker, and "Production of Liberty Motor Parts at the Ford Plants," by W. F. Verner—both contributed by the Detroit Section; "Fire Engines and the Essentials of Fire Fighting," by C. H. Fox (contributed by the Cincinnati Section); Electrical Method for Measuring the Flow of Fluids in Pipes, by J. M. Spitzglass (contributed by the Chicago Section). At the Gas Power session J. W. Morton will present a paper on "Crude-Oil Motor versus Steam Engines in Marine Practice." Simultaneous sessions will also be held on Thursday. At the Fuel session: "Pulverized Coal as a Fuel," by N. C. Harrison; "Economy of Certain Arizona Steam-Electric Power Plants Using Oil Fuel," by C. R. Weymouth; "Pulverized Coal for Stationary Boilers," by H. G. Barnhurst and Frederick A. Scheffler. At the General session: "Elements of a General Theory of Wing Design," by Walter C. Durfee; "Air Fans for Driving Electric Generators on Airplanes," by Capt. G. Francis Gray, Lieut. John W. Reed and P. N. Elderkin; "Mechanical Lifts, Past and Present and a New Method for Their Balancing," by Lieut. J. F. Robbins; "General Equations for the Design of Riveted Butt Joints," by A. A. Adler; "The Economical Section of a Water Conduit," by Cary T. Hutchinson. Arrangements have been made for trips to many of the big local plants.

Chicago Section A. S. M. E. Close Season

On May 29 at the Hotel LaSalle the Chicago Section of the American Society of Mechanical Engineers held its last meeting of the season. It was ladies' night and there was music by the orchestra and community singing. Chairman Lord read in part the report of the Aims and Organization Committee and outlined briefly some of the radical resolutions that are to be presented at the spring meeting in Detroit. These resolutions recognize the progressive thought of the day relative to the engineer and his relation to his work, the need of guiding legislation relating to engineering, and the necessity of closer coöperation between engineering bodies all along the line. One of the big things suggested was the formation of an independent organization having the power to speak for the engineering profession, this to be made up of local state and national groups of the various societies. Industrial engineering was considered technical and on a par with other engineering work.

The speaker of the evening was Dr. William S. Sadler, who gave a very interesting address on "Stress and Strain," dealing with physical engineering from the health standpoint.

For the coming season the nominating committee selected the following section officers, who were unanimously elected: A. L. Rice, chairman; J. L. Hecht, vice-chairman; G. R. Brandon, secretary; J. M. Stannard and F. A. Lindberg, other members of the executive committee.

Worcester Engineers Meet

The Worcester Section of the American Society of Mechanical Engineers held its May meeting and dinner at the Hotel Bancroft on Wednesday evening, May 28. The speakers were Major John F. Tinsley, chairman of the Worcester Fuel Conservation Committee, whose subject was Fuel Serving in Industrial Plants as Affected by War-time Necessity, and Dr. Ira F. Hollis, who talked upon Recognition for Distinguished Work in Mechanical Engineering and Encouragement toward Better Service.

Major Tinsley said that in 1917 plants his committee had recommended an average of five changes per plant, or revisions in plant or practice, 85 per cent. of which had been complied with before subsequent inspection. No recommendations were made which required new apparatus or an extensive overhauling. The principal sources of unnecessary loss were belts too tight or too loose, motors running underloaded, shafting out of line, uncovered high-pressure steam pipes, machines running idle, open doors and windows, dirty windows making more artificial light necessary. Large savings were made by revising boiler room practice and indicating engines. Much educational literature was circulated.

In the late summer or early fall of 1917, 17 plants used 31,232 tons of coal per month. In the corresponding months of 1918 the same plants used 27,104 tons with practically the same number of operatives at work. The average saving was 11.9 per cent. for the large plants, as against 21.6 for the small. Thirteen plants purchasing power used in 1917 474,841 kw.-hr. and in the same months of 1918 387,806 kw.-hr., a saving of 18.3 per cent. The six larger showed an average saving of 17.8 per cent., the seven smaller 29 per cent.

Dr. Hollis presented the results of an exhaustive study as to what the scientific and engineering societies of this and other countries are doing in the way of recognition of meritorious service; something that shall be the equivalent of the distinguished service medal, something to let one know that he stands well with the kind of men who know the kind of work that he is doing America is behind the older countries in this respect, and the American Society of Mechanical Engineers has done little beyond conferring honorary memberships and awarding prizes for papers from juniors.

Annual Convention of the N. G. E. A.

On June 2 and 3 the National Gas Engine Association held its twelfth annual meeting at the Hotel Sherman, Chicago. The convention was divided into several group sessions dealing with the commercial end of the business, the stationary and oil engine, the farm engine, the tractor, the farm lighting plant and accessories. In these various sections numerous interesting papers dealing mostly with trade and sales problems were presented. At a Victory dinner Tuesday evening the topics of discussion were "American Branch Banks Abroad" and the "Relations of Capital and Labor Before and After the War." Officers, elected for the ensuing year were: L. M. Ward, president; T. C. Menger, first vice president; Henry Kennedy, second vice president; O. M. Knoblock, treasurer; H. R. Brate, secretary; Richard De Forest, 1 year; F. E. McKee, 2 years, George Cormack, 3 years, executive committee.

Personals

Charles A. Greene, Chicago representative for The Borden Co., of Warren, Ohio, has opened an office at Room 501, 549 West Washington Boulevard, Chicago.

William L. De Baufre has resigned his position with the Naval Engineering Experimental Station, Annapolis, Md., to become designing engineer of the Precision Instrument Co., Detroit, Mich.

John R. Allen, dean of the college of engineering and architecture, University of Minnesota, has been appointed director of the Research Bureau of the American Society of Heating and Ventilating Engineers. He will take charge of the work on Aug. 1.

S. C. Orrell, recently manager of the Minneapolis office of the Allis-Chalmers Manufacturing Co., of Milwaukee, has resigned to assume charge of the Chicago office of the Murray Iron Works Co. of Burlington, Iowa.

Frederick L. Ray, who has had charge of the power plants of the Merchants' Heat & Light Co., Indianapolis, and previous to that was for nine years superintendent of steam equipment with the Louisville Railway Co., has accepted a position as superintendent of power plants of the Union Traction Co. of Indiana.

John D. Cameron, who formerly carried on a jobbing and steam supply business at Providence, R. I., has been succeeded by Cameron & Ingalls Engineering Co. at 125 Canal St., same city. Chauncey H. Ingalls, who is the additional member of the firm, has, for a number of years, been associated with the United States Finishing Co. as mechanical superintendent of its various plants, will have charge of the engineering department of the new company.

Engineering Affairs

The Canadian Association of Stationary Engineers will hold its next annual convention at Brantford, Ont., June 24-26.

The American Boiler Manufacturers' Association will hold its thirty-first annual convention at the Lafayette Hotel, Buffalo, N. Y., June 23-24. An interesting program is being arranged.

The Material Handling Machinery Manufacturers' Association will hold a coalition meeting at the Hotel Astor, New York City, on June 11, which should interest all manufacturers of mechanical handling equipment. Many speakers of note will address the meeting, and at the general "forum" discussion which will be conducted in the afternoon there will be taken up the subjects of ways and means for promoting a more general knowledge of the great economies which may be effected through the use of mechanical handling equipment, etc. A mass gathering of various clubs and city officials is planned for the evening session.

The Institution of Operating Engineers of Philadelphia held its May meeting on the 19th at the Philadelphia Yacht Club at Essington, on the Delaware River. The institution is composed of most of the chief engineers of Philadelphia; was instituted September 22, 1899, and incorporated under the laws of Pennsylvania October 13, 1899. It is now in a flourishing condition. Through the efforts of the committee the institution was tendered an invitation to visit the plant of the Hog Island Shipyard. Every member was delighted and surprised at the gigantic work that has been accomplished in so short a time at this plant. After looking through the yard, they were escorted on the ship "Sangus" which was about ready for sea. The engine and boiler room was, of course, the most interesting part of the ship to the members. After leaving the shipyard the party proceeded to the Philadelphia Yacht Club, where a bountiful repast was served. Mr. McLaughlin, the Director of Supplies of Philadelphia, made the speech of the evening. This was followed by speeches by the past presidents present, and others. There were eighty-three present, and all voted the meeting a very pleasant affair. The president this year is Robert Cheney, chief engineer of the Stock Exchange Building. The Secretary and Treasurer is Wm. D. Mahn, of Walsh Packing Co.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.75@3.25
Philadelphia, gross tons	4 27@4.9,	5.95@5.50
New York, gross tons	4 62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4 70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7 90	Pea	4 90	6 65
Egg	5 95	7 80	Buckwheat	3.40	5.15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.75 @ 2.95	2.95 @ 3.25
Clearfield County	2.50 @ 2.75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2.75 @ 2.95
Quemahoning	2.65 @ 2 85	2.95 @ 3.10
Somerset County (best grades)	2.50 @ 2 75	2 95 @ 3.10
Somerset County (poorer grades)	2 00 @ 2 35	2.50 @ 2 75
Western Maryland	2 25 @ 2 50	2.50 @ 2 75
Fairmont	2 00 @ 2 25	2.35 @ 2 50
Latrobe	2.10 @ 2.25	2 25 @ 2.40
Greensburg	2.25 @ 2.35	2.35 @ 2 60
Westmoreland	2.60 @ 2.75	2.60 @ 2.75
Westmoreland run-of-mine	2.35 @ 2.60	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6 05	7.90	Rice	2.75	3.65
Stove	6.30	8 15	Boiler	2.50	3 50
Nut	6.40	8.25	Barley	2.25	3 15
Pea	5.00	6.60	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2 40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.95@$4.60
Corona	3.50
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2 75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2 55	$2 55	$2 00@2 25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	..
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; hoter rates 92½c.

New Construction

PROPOSED WORK

N. H., Nashua—The Nashua Manufacturing Co. will install a steam heating plant in the 7 story, 122 x 560 ft. factory which it plans to build. Total estimated cost, $750,000. Lockwood-Greene & Co., 101 Park Ave., New York City, Engr.

Mass., Springfield—The National Equipment Co., 662 North Main St., has awarded the contract for the construction of a 3 story, 100 x 372 ft. factory, to A. E. Stephens Co., 128 Chestnut St. A steam heating system and electric power will be installed in same. Total estimated cost, $100,000.

Conn., Bridgeport—The Columbia Graphophone Co., Barnum Ave., will install a steam heating plant and electric power in the 6 story, 80 x 240 ft. factory which it plans to build. Total estimated cost, $200,000.

Conn., Greenwich—R. A. Cowles, c/o F. F French Co., Arch., 299 Madison Ave., New York City, will install a steam heating plant in the 12 or 15 story hotel which it plans to build on Boston Rd. and Greenwich Ave. Total estimated cost, $1,000,000.

N. Y., Brooklyn—The Avondale Building Co., c/o Shampan & Shampan, Arch., 50 Court St., will install a steam heating plant in the theatre which it plans to build on Coney Island Ave. and East 12th St. Total estimated cost, $250,000.

N. Y., Brooklyn—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until June 11 for building an extension to the heating plant and distribution system at the Naval Hospital here. Estimated cost, $830,000. Specification No. 3891.

N. Y., Brooklyn—B. A. Cushman Sons, Inc., 49 Manhattan St., New York City, will install a steam heating plant in the 3 story, 140 x 200 ft. bakery which they plan to build on Atlantic and Troy Ave. Total estimated cost, $100,000. L. S. Beardsley, 40 West 32nd St., New York City, Engr.

N. Y., Brooklyn—Parshelsky Bros., Johnson Ave., will install a steam heating plant in the 1 story, 200 x 200 ft. factory which it plans to build on Morgan and Montrose Ave. Total estimated cost, $150,000. L. Allmendinger, 20 Palmetto St., Arch.

N. Y., Cohoes—The Board of Education received bids for installing heating plant in the high school, from C. Dwyer, 18 Chuctanunda St., Amsterdam, $29,253. Tooker & Marsh, 101 Park Ave., New York City, Engr. Noted Jan. 14.

N. Y., New York—J. Eichler Brewing Co., 3582 3rd Ave., has had plans prepared by A. G. Koenig, Engr., 405 Lexington Ave., for altering its 3 story, 62 x 84 ft. ice plant on 169th St. near 3rd Ave. Estimated cost, $37,000.

N. Y., New York—D. L. Elliman & Co., 15-17 East 49th St., will install a steam heating plant in the 10 story, 34 x 100 ft. office building which it plans to build on 49th St., between 5th and Madison Ave. Total estimated cost, $150,000. Cross & Cross, 681 5th Ave., Engr.

N. Y., New York—The W. Fox Film Corp., 126 West 46th St., will install a steam heating plant in the 3 story, 100 x 190 ft. studio which it plans to build on 10th Ave., between 55th and 56th St. Total estimated cost, $1,000,000. Owner will build by day labor under the supervision of A. Allen, 128 Broadway, New York City, Representative.

N. Y., New York—The League of Political Education, 15 West 44th St., will install a steam heating plant in the 5 story, 100 x 125 ft. institute which it plans to build on 43rd St. and Broadway. Total estimated cost, $150,000. McKimm, Mead & White, 101 Park Ave., Arch.

N. Y., New York—F. W. Schweirs & Sons, 52 Vanderbilt Ave., will install a steam heating plant in the 3 story, 100 x 100 ft. warehouse which it plans to build on 11th Ave. and 48th St. Total estimated cost, $100,000. R. T. Lyons, Inc., 52 Vanderbilt Ave., Arch.

N. Y., New York—The Springfield Tire Co., 200 West 57th St., will install a steam heating plant in the 4 story, 100 x 115 ft. warehouse and 1 story, 60 x 100 ft. service station which it plans to build on 10th Ave. and 54th St. Total estimated cost, $100,000. E. Necarsulmer, 507 5th Ave., Arch.

N. Y., Salamanca—The Board of Education is receiving bids on installing a new lighting and ventilating system in the Maple School. Estimated cost, $16,000.

N. J., Jersey City—The Board of Commissioners plans to install a steam heating plant in connection with building an addition to the hospital on Baldwin Ave. and Montgomery St. Total estimated cost, [illegible] F. Sutton, 80 Broadway, New York City, Engr.

Penn., Shenandoah—The city is having plans prepared by Gannett, Seelye & Fleming, Engrs., 204 Locust St., Harrisburg, for improving the waterworks system, to include pumping station pumps, motor, etc. D. T. Glover, City Engr.

La., New Orleans—The American Sugar Refining Co., [illegible] North Peters St., plans to remodel its power plant and install new dynamos and machinery.

Ohio, Cleveland—W. Vretman, 413 Engineers Bldg., will install a steam heating plant in the 2 story, 95 x 120 ft. commercial building and theatre which it plans to build on West 117th St. and Lorain Ave. Total estimated cost, $125,000. Whitworth & Johnson, 413 Engineers Bldg., Arch.

Ohio, Kent—The Kent Hotel Co. has awarded the contract for the construction of a 3 story hotel, to the Crowell-Lundoff Little Co., 5716 Euclid Ave., Cleveland. A steam heating plant will be installed in same. Total estimated cost, $150,000.

Ind., Perrysville—The Perrysville Stove Works is in the market for a motor for machine shop, blower for cupelo and traveling crane, etc.

Mich., Marquette—The City Commissioners will receive bids until June 16 for the construction of a light and power plant. T. W. Orbison, Appleton, Engr.

Mich., Royal Oak—The Board of Education, Peter Smith Bldg., Detroit, will install a steam boiler, pump and accessories in the school which it plans to build on Berkley Ave. C. A. Dunton, Pres. Van Leyen, Schilling & Keough, 1115 Union Trust Bldg., Detroit, Arch.

Ill., Chicago—The Independence State Bank, 1215 South Kedzie St., has awarded the contract for the construction of a 3 story, 66 x 118 ft. bank on 12th St. and Kedzie Ave., to R. Sollit & Sons Construction Co., 5 South Wabash Ave. A steam heating plant will be installed in same. Total estimated cost, $125,000.

Ill., Chicago—J. L. Kraft Bros. Cheese Co., 359 River St., will install a steam heating plant in the 6-story, 120 x 275 ft. factory which it plans to build on Oak and Crosby St. Total estimated cost, $500,000. Architect not selected.

Ill., Chicago.—The National Tea Co., 2715 West North Ave., will install a steam heating plant in the 6-story, 120 x 125 ft. warehouse which it plans to build on Oak and Crosby St. Total estimated cost, $275,000. J. B. Bohm & Son, 138 North La Salle St., Arch.

Wis., Sheboygan—The Wadham Oil Co., 339 Clinton St., is in the market for several pumps and [illegible] centrifugal gas tanks to be installed in the 2 story, 60 x 150 ft. warehouse which it plans to build on Michigan Ave. Lesser & Holst, 105 Wells St., Milwaukee, Arch.

Wis., Sheboygan—C. A. Honold, 821 Pennsylvania Ave., will receive bids until June 15 for the construction of a 40 x 30 ft. storage battery and electrical station. Estimated cost, $20,000. Engineer not selected.

Minn., Albert Lea—C. J. Dudley, City Clk., will soon award the contract for building a 1,500,000 gal. reservoir, 125,000 gal. tank and tower, both 800 gal. per minute, centrifugal pump direct conected to a 15 h.p. steam turbine, piping, valves and water mains, etc. Estimated cost, $50,000. J. H. A. Brahtz, 506 Chamber of Commerce Bldg., St. Paul, Engr. Former bids rejected.

Minn., Hibbing—The Oliver Mining Co., Wolvin Bldg., Duluth, will install a steam heating plant with mechanical ventilating system in the 3 story, 45 x 150 ft. hospital which it plans to build on 4th Ave. and Mesaba St. Total estimated cost, $250,000.

Kan., Hays—The state, c/o J. A. Kimball, State House, Topeka, will receive bids until June 10 for one 250 hp. auto horizontal side crank engine, 275 r.p.m., 100 lb. pressure, 4 valve or uniform type, with one 150 k.v.a., 200 v, 60 cycle, 3 phase d.c. generator; two 25 k.w. and two 15 kw., 220 to 110 volts transformers; also an auto lubricating system. R. S. Gamble, Topeka, Arch.

Kan., Kansas City—The city will receive bids until June 18 for one 10,000 or one 6,000 k.w. turbo generating unit; two 600 hp. water tube boilers and auto stokers; 1 turbine driven boiler feed pump; and 1 brick and concrete transformer house; 1 sub-station complete poles, coffers and material for new lines. A. H. Strickland, Purch. Agt. W. Barclay, City Engr.

Kan., Oswego—The city voted $50,000 bonds for the construction of a light and power plant. Plans include the installation of oil burning engines of sufficient capacity to take care of the growth of the town for many years. Noted March 25.

N. D., Leeds—The city plans to build a 500,000 gal. steel tank on a 100 ft. steel tower, a 100,000 gal. reservoir and settling basin; brick pump house and also the installation of a 100 gal. per minute pump with engine, etc. Estimated cost, $35,000.

Mo., St. Louis—The Argonne Realty Co., 2407 North Broadway, will install a steam heating plant in the 5 story, 62 x 219 ft. hotel which it plans to build at 3664 Washington St. Total estimated cost, $250,000.

Mo., St. Louis—The Maxwelton Amusement Co., c/o the Lindell Theatre, Grand and Herbert St., plan to convert the mercantile building into a theatre and install air cooling and ventilating system in same. Total estimated cost, $110,000. W. Goldman, Pres.

Mo., St. Louis—R. M. Milligan, Commissioner of School Buildings, 9th and Locust St., is receiving bids for furnishing and installing 5 electric generator units in St. Louis high schools, 3 units to be 3 phase, alternating current motor drive, 125 hp. at 40 rating; 2 units to be 3 phase, alternating current motor drive, 100 hp. at 40 rating; motors to be 3 phase, 60 cycle, 220 volt wound rotor with slip rings having a synchronous speed of 900 r.p.m. and loaded capacity speed of 855 r.p.m. Belting to be of endless and high grade double oak tanned leather with a short lap of not less than 12 in. wide. Pulleys to be regulation Rockwood paper pulleys, heavy duty, 2 minute starting drum. Concrete foundations and iron railings required for each motor, bases to be not less than 18 inches in thickness.

Cal., Anaheim—E. B. Merritt, City Clk., will soon award the contract for furnishing a 1350 ft. 12-in. and 300 ft. 4-in. c.i. water pipe; also a deep well pump and motor.

Cal., Inglewood—The city voted $217,000 bonds for the construction of a waterworks system. Plans include the installation of wells, pumps, stand pipe, reservoir and distribution system, or the purchase of pumping plant and distribution system of the Inglewood Water Co. and extending and improving same. Olmsted & Gillelen, 1113 Hollingsworth Bldg., Los Angeles, Engrs. Noted April 1.

P. E. I., North Wiltshire—The Department of Public Works, Ottawa, Ont., will soon award the contract for the construction of a pump house, vocational building, etc., at the Dalton Sanitorium here. R. C. Desrochers, Secy.

Ont., Larder Lake—The Associated Gold Fields Mining Co., Toronto, plans to build a 10,000 hp. hydro-electric power plant here. A. J. Moore, Barnes St., Gouverneur, N. Y., Supt.

CONTRACT AWARDED

Conn., Waterbury—The American Brass Co., Grand and Meadow St., has awarded the contract for the construction of a 1 story power house on Washington Ave., to H. R. Kent Co., 141 Broadway, New York City. Estimated cost, $60,000.

N. Y., Watertown—The Beebes Island Power Corp. will build a new 7000 hp. electric generating plant. Estimated cost, from $30,000 to $50,000. Work will be done by day labor.

Penn., Hershey—The Hershey Chocolate Co. will build a 4,000 hp. power plant. Work will be done by day labor.

Ohio, Cleveland—The Jordan Motor Co., 1010 East 152nd St., has awarded the contract for the construction of a 1 story, 40 x 60 ft. power plant to the Hunkin-Conkey Co., 601 Century Bldg. Estimated cost, $40,000.

Mo., St. Louis—Swift & Co., 866 South Vandeventer St., has awarded the contract for the construction of a 1 story, 50 x 165 ft. boiler house at 746 South Vandeventer St., to the Collins Bros., 536 Rialto Bldg., Kansas City. Estimated cost, $19,000. Noted April 22.

"Opportunity" Advertising

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SEE PAGES 47 TO 59

POWER

Volume 49 New York, June 17, 1919 *Number* 24

SAFETY FIRST IN THE POWER PLANT

By WALDO WEAVER

Considerable attention should be given to safety in the power plant, as one accident usually costs many times more than lavish expenditures for the purpose of preventing such accidents.

Economy in design or in repairs is too often responsible for very serious disasters, which disasters are afterward referred to as unfortunate.

Power-plant designers and operators should always keep in mind that the best is none too good.

BOILER ROOM

1. Make it a rule that firemen or water tenders shall not indulge in lengthy conversations, as such cause them to forget their duties.

2. Chains attached to quick-closing gage-glass valves should be of such length that firemen must reach above their heads to pull them shut. On one occasion a man was observed in the act of pulling the valves shut while talking to the fireman. He unconsciously had used the chain as a rest.

3. Impress upon firemen and water tenders that they must blow water columns when coming on duty. This old rule is too often disregarded in large plants.

4. Boiler cleaners and repairmen should be given strict orders that they must never enter a boiler without first telling the fireman in charge and see to it that blowoff valves and feed valves are shut tight.

5. In large plants no person should be allowed to crawl into a furnace or boiler without first advising the chief fireman.

6. When boilers are dropped for cleaning and repairs, both steam-nozzle valves should be closed tight. Plug valves on feed-water lines should also be closed, as firemen or water tenders have opened the feed valves on dead boilers by mistake.

7. Provide stationary steel ladders on both sides of all boilers, preferably one at the front and one at the back. Exit to the boiler-house roof should also be provided.

8. Never permit ash handlers to crawl into ashpits. If the design used makes this necessary, change the design. Conveyors adapted to the layout usually save their first cost in the first year

9. Boiler-room basements in large plants should be provided with several avenues of escape in case a tube or a steam pipe should burst. The men should be taught to use all exits.

10. Stairways should be properly illuminated, so as to prevent stumbling.

11. Electric hand lanterns should be hung at suitable locations for use when the lights go out. Large sizes should be provided so that employees will not take them home.

12. Doors to furnaces should be provided with safety automatic latches. This should be applied to underfeed-stoker doors, as men have been painfully burned while dumping fires. Neglecting to close damper in duct to overfeed element will cause this Various makes of stokers should be so equipped as to prevent coals and fire from being blown out at the front when a tube lets go.

13. Bucket conveyors should be properly protected. Crossover platforms with guard rails should be installed. Workmen should be cautioned against crawling over conveyors.

14. Boiler-room employees should be cautioned against stepping into water, as it may be scalding hot.

15. Kidding, goosing and playing tricks should be absolutely prohibited. Costly litigation has resulted from injuries incurred while playing.

16. Damper counterweights should be hung close to the floor, to keep workmen from being struck by a falling weight.

17. Adequate sewers should be installed and should be kept clear.

18. Large plants should employ a power-house inspector to give special attention to safety first in the power plant.

ENGINE AND PUMP ROOMS

1. Engine or turbine throttle valves should turn easily, so that they may be closed quickly in case of emergency. Valves that can be opened or closed only by a bar or a monkey wrench are packed too hard. Valves should not be opened with a spin, as certain makes of valves have a tendency to lock in an open position. It is advisable to teach operators to close all valves one turn after opening to prevent such a possibility.

2. Emergency engine and turbine overspeed devices should be inspected and used at least once each week.

3. Many wrecks could be averted by making periodical inspections. Strange knocks and noises in engines should be followed up immediately.

4. Hourly and half-hourly patrols of operators in filling in logs are instrumental in preventing hot bearings, accidents, etc.

5. Steam headers are too often neglected. Experts should be called in if necessary to overcome dangerous vibration.

6. Foot valves of pumps are generally neglected. These should be inspected, cleaned and repaired at least once each year.

7. Centrifugal boiler-feed pumps fail at the critical moment because they have not been inspected, cleaned and repaired.

8. Centrifugal fire pumps have been known to be shut down or wrecked because the oil cooler was allowed to fill up with mud, causing the oil to get hot and foam out, resulting in hot bearings and wrecked blading.

9. Engines, turbines and pumps have been wrecked and ruined because relief valves were not installed or because they had been in disuse so long that they failed to function when the emergency occurred. Relief valves should not discharge in such directions as to endanger workmen.

10. Steam traps are too often located in out-of-the-way places. When installed in basements or cellars, bright lamps should be located directly over them. Traps should be blown out daily and inspected not less than once in ninety days. The packing of the trunnion stuffing-boxes of tilt traps should be removed and new packing applied once or twice yearly, as conditions may demand.

11. Overflows and ball floats should be inspected, cleaned and repaired when the feed-water heater is cleaned, as heaters have been blown up due to becoming filled with water and setting up water-hammer.

12. Air compressors should not be over-lubricated, as excess oil has caused very disastrous explosions. The air intake should be screened and the air supply taken from a point where it will be free from dust. Where concrete or brick ducts are used for intakes, they have been known to crack, crumble and fall down, due to vibration. Intercoolers and aftercoolers should be inspected and washed at proper periods.

13. Too much care cannot be given to protecting operating engineers and switchboard operators. Rubber mats should be provided both in front and back of switchboards. Cable joints, splices and connections at generators, motors, etc., should be heavily covered to prevent shock. In this connection it is best to teach operators to let alone those things back of the board which they do not thoroughly understand.

Refrigerating Plant No. 1, American Expeditionary Forces

By LIEUT. JOHN V. FISHER, A. E. F.

LIEUT. JOHN V. FISHER
Chief Engineer

THIS six hundred-ton refrigerating capacity plant, operated by the Quartermaster Corps of the A. E. F., is located in the departure yard of the American Docks at Bassens, near Bordeaux, France. Construction began June 1, 1918, and the first refrigerating machine was put into operation Oct. 29, 1918. On Nov. 8 the first carload of beef was unloaded into the plant. Thus in the incredibly short space of five months there had been erected one of the most modern cold-storage plants in existence with material which, excepting for the cork used in the insulation of the rooms, had all been transported from the United States to France. It has a total capacity of six thousand tons of beef quarters or ten thousand tons of box meats; 24,000 head of carcass beef could be stored in its rooms, sufficient to feed an army of one million men for sixteen days. Most of the meat shipped to this plant is carcass beef wrapped in cheesecloth and then covered with burlap. Recently, however, boneless beef boxed is being received. The beef is boned and boxed in the packing plants in the United States and labeled "Hinds" and "Fores." Twenty per cent. of the carcass is bone, and by packing beef in this manner a similar saving in cargo space is effected.

The direct-expansion system of refrigeration is used throughout the plant. The refrigerant is ammonia. The plant proper consists of two main buildings, one containing the coolers or storage rooms and the other the mechanical equipment.

The storage building is 704 ft. in length and 112 ft. in width. It is divided into four separate rooms with loading dock surrounding the north and south sides and east end of the building. A corridor 8 ft. wide, with an insulated wall separating it from the main rooms, extends the entire length of both sides. The construction is of wood excepting the cork used for the insulation. The ceiling is 12 ft. high, and a thoroughly ventilated loft forms the roof of the building. Approximately six inches of cork insulation is used throughout. The floor has a layer of concrete 5 in. thick on top of the insulation. Suspended from the roof in each room is approximately 70,500 ft. of 2-in. pipe, divided into eleven sets of coils, each coil connected into a common header. Installed in each corridor is 22,600 ft. of 2-in. pipe, divided into four sets of coils connected into the room header. Two separate 1½-in. lines cross-connected take care of the liquid-ammonia supply. All section headers connect into two cross-connected 6-in. lines running directly through two accumulators to the ice machines. All ammonia lines are covered where necessary with sectional molded Nonpareil cork insulation. The joints are hermetically sealed with special cement. Suitable provision is made for expansion of all lines throughout the plant.

The engine room is 150 ft. long, 53 ft. wide and 26 ft. high. It is constructed of structural steel framework with outside wood sheathing. The boiler room is adjacent to the engine room, with a fire wall between.

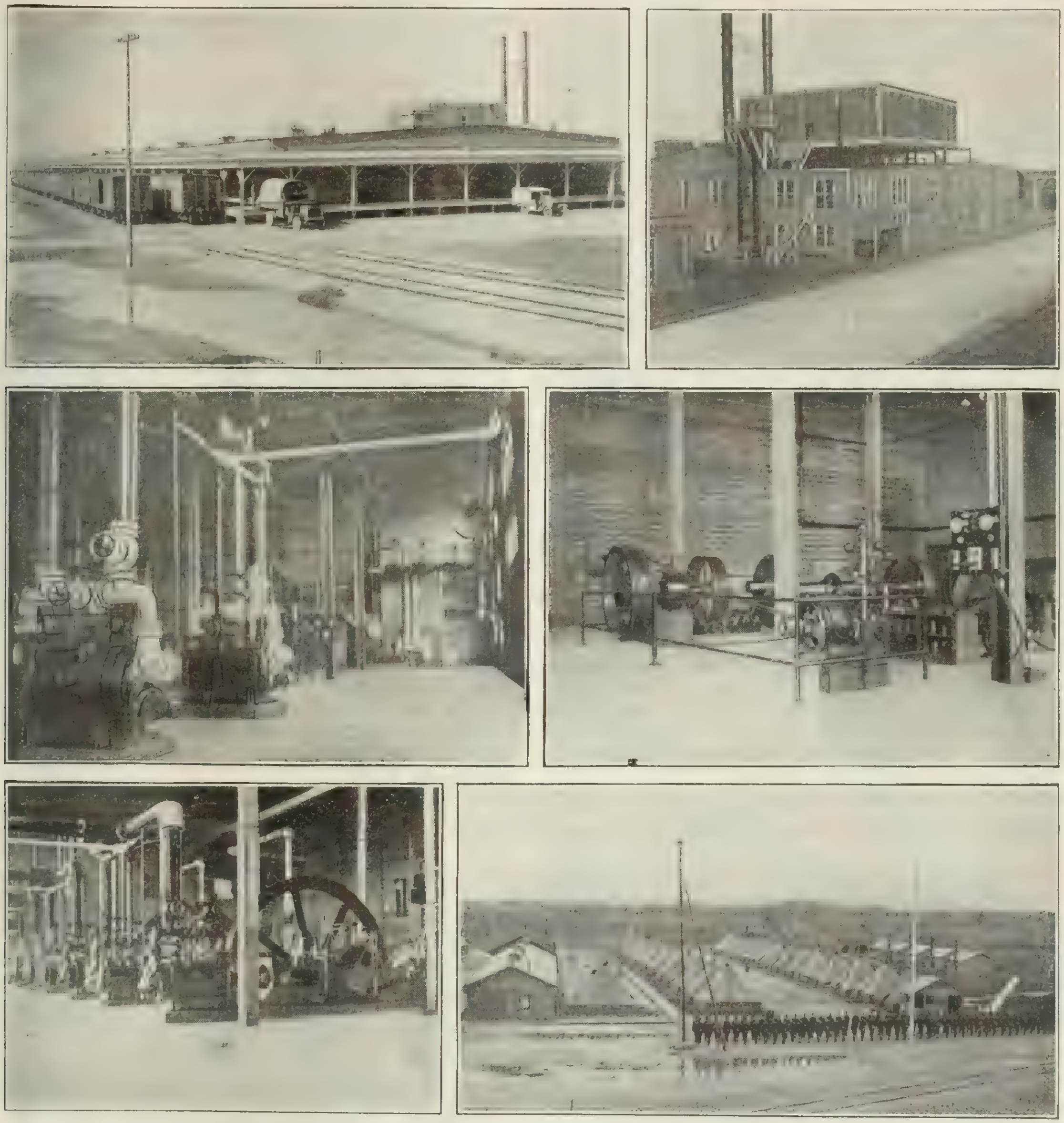
There are four 225-hp. return-tubular horizontal water-tube boilers connected in batteries of two each with one smoke-stack 57 in. in diameter and 85 ft. high for each battery. Each boiler has 110 4-in. tubes. The grates are of the hand-shaking type with an area of 49 sq.ft. The boilers are designed for a working pressure of 150 lb., and are fitted with mechanical flue blowers, automatic shutoff steam valves, blowoff valves and blowoff cocks. The boiler-feed system consists of two duplex steam pumps and one 2½-in. steam injector, all cross-connected to pump through two individual feed lines. An 8-in. steam header is connected to the ice machines by a 6-in. line fitted with steam separators and suitable traps. Draft gages, pyrometer and Orsat flue-gas testing apparatus form part of the boiler-room equipment. The feed-water heater is of the open type and has a capacity of 1200 horsepower.

The engine-room equipment consists of three Vilter ammonia compressors each of 200 tons refrigerating capacity, at 15 lb. suction pressure and 185 lb. condenser pressure, driven by cross-compound condensing steam engines. Steam and exhaust piping are so connected that either cylinder can be operated independent of the other. All machines are equipped with gravity oiling system and steam cylinders with force-feed lubricators. Steam and ammonia rods and valve stems are packed with metallic packing throughout.

BAROMETRIC-TYPE STEAM CONDENSER

The steam condenser is of the barometric type with a condensing capacity of 20,000 lb. of steam per hour. Condensing water is drawn from a storage tank on the engine-room roof, which collects the water flowing over the ammonia condensers. This water is pumped from the condenser by a reciprocating steam pump having a capacity of 15,000 gal. per min., drawing from a 150,000-gal. capacity concrete reservoir. The surplus water from the ammonia condensers not used in the steam condenser is circulated through a separate cooling system on top of the reservoir, effecting a large saving in the water consumed. The main water supply to the plant is pumped from an artesian well in the immediate vicinity. In addition to this a 12-in. line can be opened from the pumping station at the Gironde River, a distance of approximately 6000 ft. from the plant. In addition to the reciprocating steam pump a 2000-gal. per min. steam-turbine driven centrifugal pump suitably connected is held in reserve. A steam-driven reciprocating air pump withdraws the air and vapor from the steam condensers.

An atmospheric-type ammonia condenser erected on the roof of the engine room consists of four banks of five coils each, 20 ft. long, 24 pipes high, of 2-in. wrought-iron pipe. Each coil is provided with a purge valve and each bank with inlet and outlet valve. Two banks of five coils each are connected to a common header. Each bank is supported with cast-iron stands. The cooling water is distributed from galvanized iron troughs.



VIEWS OF REFRIGERATING PLANT NO. 1, A. E. F., NEAR BORDEAUX, FRANCE

Top, left: Beef storage house, power plant in the right background. Middle, left: View of the compressor room. Bottom left: Another view showing a line of compressors. Top, right: Exterior of compressor plant, showing cooling tower. Middle, right: Pistons, motors, pulleys and other spare parts. Bottom, right: The refrigerating company and camp, near the plant.

There are three 24-in. diameter by 15-ft. long liquid ammonia receivers installed on the engine-room roof below the ammonia condensers, and a 600-ton capacity ammonia purifier is installed in the engine room. This consists of a cylindrical tank with internal steam coils. All discharge lines are equipped with suitable oil separators, which connect into the aforesaid purifier. Installed in the main suction lines with suitable bypasses are two ammonia accumulators. These serve the double purpose of trapping liquid ammonia which might get through into the compressors and precooling the liquid after leaving the receivers on its way to the expansion coils. Any liquid that is not evaporated in the precooling of the ammonia is returned to the ammonia receivers by a steam-driven reciprocating pump.

One 9 x 9-in. pump-out compressor, driven by a 10 x 11-in. steam engine enables any part of the system to be pumped out without affecting the operation of the main ice machines. This is accomplished through suitable pump-out lines connecting all parts of the high- and low-pressure system.

A duplicate system of lighting is in use, one source being supplied by the French central station, alternating current system, the other from a direct-current generator operating in the plant. Previous to the installation of the direct-current equipment much trouble and inconvenience were experienced through the interruption of the central-station service, caused by the big cranes at the American Docks blowing the fuses on the "French" switchboard.

Where necessary, all steam lines throughout the plant are insulated with 85 per cent. magnesia steam-pipe covering.

Spare parts are on hand for all engine-room equipment, including ice-machine crankshaft, steam and ammonia pistons, cylinder heads and connecting-rods.

In the vicinity of the engine room a machine shop, equipped with all necessary iron and woodworking tools, is in operation. Close by is the blacksmith shop and oil-storage house, each separated from the other buildings for fire protection. An efficient fire-fighting system is available throughout the plant.

The railroad-trackage system consists or five spur tracks, running from and forming a loop with the main American line. One track runs directly in front of the coal-storage bin at the boiler room, one by the south side of the engine room, one by the north beef-loading dock, and two by the south beef-loading dock. It is possible to load eighteen American refrigerator cars at each dock at the same time, while trackage facilities permit of the storing of one hundred cars.

DIMENSIONS OF EQUIPMENT

Steam boilers		84 in dia. x 18 ft. long
Pump out machine	Steam	10 in. x 11 in.
	Ammonia	9 in x 9 in.
Ice machines	Steam	22 in x 42 in. x 32 ft
	Ammonia	16 in x 32 in
Terry steam turbine		90 hp , 1800 r p.m
Boiler-feed pumps, outside-packed duplex		12 x 7 x 10 in.
Vacuum pumps, steam driven		6¾ x 14 x 6 in.
Liquid ammonia, simplex, steam-driven		10 x 4½ x 10 in.

It might be mentioned that during a period of nine hours 85 men handled a total of 1,600,000 lb. of beef. It is believed this record has never been equalled.

The camp in connection with this plant shelters 200 men under canvas and has barrack-building housing for 103 men. Running hot and cold water is supplied for kitchens and washrooms of the camp.

Drainage is effected by an efficient sewerage system. Where necessary grease traps or catch basins have been installed. An intercommunicating telephone system is in service in addition to the main outside lines.

The storage rooms are held at 10 deg. F. Engine and boiler-room crews work 8-hour watches. Steam and ammonia cylinders on the ice machines are indicated regularly. Ammonia suction, steam condenser, and all low-pressure gages have a permanent connection to a mercury column. The sump in tunnel pit is drained by automatic steam siphon (all exhaust pipes in a tunnel).

LIST OF FIRE-FIGHTING EQUIPMENT

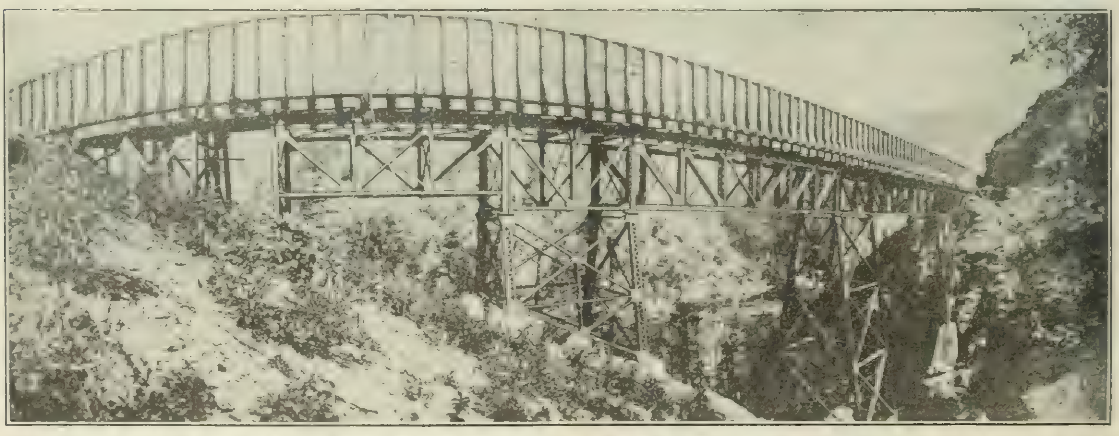
1	1500 gal per min Worthington fire pump
	2000 ft of fire hose
4	Portable hose reels
13	Fire axes
30	Pyrene extinguishers
40	Fire buckets.
3	50 Gal chemical extinguishers

Feed water is maintained, with auxiliaries operating, around 208 deg. to 210 deg. F. No scale deposits in the steam boiler—in feed-water heater only, which is cleaned out regularly. Every pound of coal consumed in the boilers is weighed. The temperature of artesian-well water is 70 deg. F., all the year round (used in plant). Ice-machine operation is regulated by thermometer readings taken from suction and discharge lines. The ice machines are fitted with revolution counters. Temperature and all other data readings are taken every hour.

It is of interest to note the thoroughly American fashion in which beef is handled. All beef taken into this plant has been shipped from the United States, crossing the ocean in American-built refrigerated ships, which arrive at the American docks at Bassens. From here the beef is transferred to this plant in American cars over the rails of the American railroad. Later, it is distributed throughout France and the American-occupied territory of Germany in American refrigerator cars.

Since Nov. 7, 1918, there have been taken into the plant 68,000,000 lb. of packinghouse products, and shipped out to various organizations in the A. E. F., 59,000,000 pounds.

Flume of Tennessee Power Company on the Ocoee River, Eastern Tennessee



The flume shown is used to convey water diverted from the Ocoee River to a point on the hill site below where a fall of 254 ft. is obtained. This flume is 14 ft. 2 in. wide by 10 ft. 9 in. deep, inside dimensions, and has a capacity of 1200 cu.ft. per sec. The water passing through this flume is now used by two 10,000-hp. turbines. Power is transmitted to Chattanooga, Knoxville, Nashville and other cities in eastern Tennessee. The engineering and construction work was done by The J. G. White Engineering Corporation, New York to whom *Power* is indebted for the photograph

A Simple Method of Determining Power-Factor Correction

By RALPH KELLY

Power factor is a feature in power-plant operation that is of ever-increasing importance to the operating engineer. Therefore a simple method of determining the power factor of a combination of loads each having different power factor should prove of interest.

The problem of correcting the power factor of a power line of known characteristics can be solved by the vector addition of straight lines and graphically represented by combining the different inductive and corrective kilovolt-ampere (kv.-a.) loads. This method is easily comprehended and consists in the actual plotting of the various kv.-a. loads in their logical sequence, with their correct values and direction.

The fundamental graphic representation of a given load of 1000 kv.-a. at 80 per cent. power factor for value and direction is shown by the line *OA* in Fig. 1, which is proportional to the kv.-a. The angle of the line *OA* with *OB* is such that the cosine of the angle *AOB* is 0.80, which fulfills the requirements of 80 per cent. power factor.

The most convenient way of determining the direction of any kv.-a. load to correctly conform to its power factor is by the use of a "unit circle," or a circle whose radius is unity; *XY* in Fig. 1 is a quadrant of such a circle. The projection of any radius on the horizontal center line is accordingly the cosine of the angle between the radius and center line, such as the projection of the radius *OC* on the center line *OB*. In other words, if the radius *OC* is drawn at an angle to the center line *OB*, the cosine of which equals 0.80, then the projection of the radius *OC* on *OB*—that is, *OD*—equals 0.80 the length of *OC*.

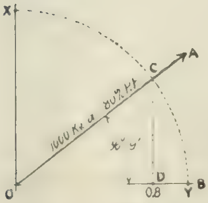


FIG. 1. VECTOR DIAGRAM OF A SINGLE LOAD ON A SYSTEM

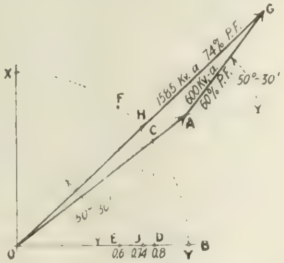


FIG. 2. VECTOR DIAGRAM OF TWO LOADS ON A SYSTEM

Thus to graphically represent a load with a given power factor it is only necessary to plot the power factor from the center *O* on the horizontal center line of the unit circle; then project upward to the circle. The line through the origin *O* and the intersection of the upward projection with the circle is correct for direction of the kv.-a. line. The kv.-a. is represented by the length of that line in suitable units. Lines which have a direction above the reference line *OB* represent inductive loads, and lines which have direction below *OB* represent corrective loads. Accordingly, loads which have the direction *OB* represent kilovolt-amperes at unity power factor, or kilowatts; while vertical lines represent reactive kilovolt-amperes either inductive or corrective, depending on whether their direction is above or below *OB*.

A typical power line consists of a number of kv.-a. loads at various power factors, but these may be combined in a total load and power factor equivalent to the resultant of the individual loads similar to that of Fig. 1. The resultant load on a power line is found by obtaining the vector sum of these individual loads. For example, assume that a line has an inductive load of 1000 kv.-a. at 80 per cent. power factor, as in Fig. 1, and another inductive load of 600 kv.-a. at 60 per cent. power factor. The vector addition of these loads is shown in Fig. 2. To do this, first, with *O* as a center draw the quadrant *XY* with any convenient radius and call the length of this radius unity. Next lay off on *OB*, from *O*, lengths equal to the power factors of the loads. In this case *OE* = 0.60, and *OD* = 0.80 part of *OB*, equal to the power factors of the 600-kv.-a. and the 1000-kv.a. loads respectively. Next at *D* and *E* draw vertical lines upward; these will intersect the quadrant at *C* and *F* respectively. Lines drawn from *O* through *C* and *F* will give the correct direction of the 1000- and 600-kv.-a. load lines respectively. Lay off *OA* equal to the 1000-kv.-a. load, then from *A* draw *AG* parallel to the 600-kv.-a. load line *OF* and make *AG* equal to the 600 kv.-a. load. If *OA* represents to scale 1000 kv.-a., then *AG*, which represents to scale 600 kv.-a., will be 0.6 of *OA*. Then draw *OG*, and this line will represent to scale the resultant kv.-a. load on the system, and the projection of *OH* on *OB* will give the resultant power factor. The resultant of these two loads in the line is *OG*, which has a value of 1585 kv.-a. and intersects the unit circle at a point whose horizontal projection on *OB* is 0.74. In a similar manner any number of different loads with varying power factors, either inductive or corrective, may be combined to obtain the resultant load and power factor on a line.

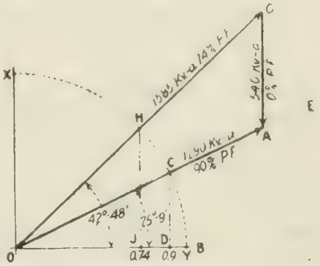


FIG. 3. CORRECTIVE LOAD ADDED TO POWER LINE

Consider next the correction of a power line of low inductive power factor by the addition of a synchronous condenser, by assuming that it is desired to correct the power factor of the line represented in Fig. 2 by *OG*, and to find the effect of the addition of a 540-kv.-a. synchronous condenser on the characteristics of the line. The line *OG* in Fig. 3 is the same in value and direction as in Fig. 2, and to this line is added to scale the 540-kv.-a. condenser load, at 0 per cent. leading power factor, in its right direction, which is vertically downward. The kilowatt loss of the synchronous condenser is neglected, as it is small in proportion to the total kv.-a., therefore it but slightly affects the result. The vector sum of the inductive load *OG* and the condenser load *GA* is the line *OA*, which has a measured value of 1290 kv.-a. and intersects the unit circle at a point *C* such that its power factor is 90 per cent. In a similar manner the effect of adding any synchronous condenser to any power line may be determined.

In correcting the line power factor where it is desired to find the condenser kv.-a. required to correct a power line of given characteristics to a given higher power factor, this is obtained in a manner similar to the calculation in Fig. 3. For example; to find the condenser kv.-a. capacity required to correct the 1585-kv.-a. load at 74 per cent. inductive power factor, Fig. 2, to 90 per cent. power factor. The given load is drawn with its correct value and direction, and then a line *OE*, Fig. 3, is drawn such that its angle with *OB* has a cosine of 0.90. The vertical distance between *G* and the line *OE* drawn to the correct scale is the condenser kv.-a. that is required to be added to *OG* to correct the line power factor to 90 per cent., which in this problem is 540 kv.-a. Similarly, the condenser kv.-a. required to correct any resultant load at any inductive power factor to any higher power factor can readily be determined.

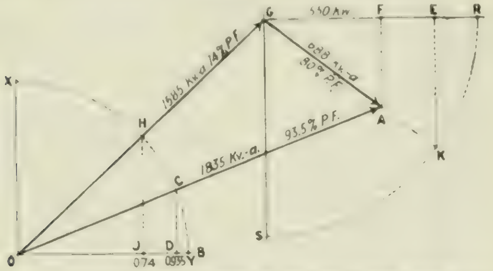


FIG. 4. SYNCHRONOUS-MOTOR GENERATOR SET LOAD ADDED TO POWER LINE

Another common problem in connection with power-factor correction is that of calculating the effect of adding to an inductive line a synchronous motor-generator set operating at leading power factor. This is shown in Fig. 4, and the result is obtained by the vector addition of the two loads. A power line with the characteristics of *OG* in Fig. 2 is selected, and to that line is connected a 500-kw. synchronous motor-generator set which operates at 80 per cent. leading power factor. In this case the loss of the set is that of two machines and should be considered for reasonable accuracy. A value of 10 per cent. for the motor-generator set losses is a sufficiently accurate figure for a set of this type. The kilowatt input of this machine will be 500 + (10 per cent. of 500) = 550 kilowatts. To determine the kv.-a. input at 80 per cent. leading power factor and 90 per cent. efficiency, draw *GR*, Fig. 4, making it equal to any convenient unit radius. Then with *GR* as a radius draw the quadrant *RS* and taking *GE* equal to 0.80 corresponding to the 80 per cent. power factor of the motor-generator set, drop a vertical line from *E* intersecting the quadrant at *K*. A line drawn from *G* through *K* will represent the correct direction of the kv.-a. line of the motor-generator set at 80 per cent. power factor. To determine the kv.-a. length of this line, lay off on *OR*, *OF* representing to scale the 550-kw. load on the motor-generator set, and from *F* drop a vertical line. This will intersect the line *GK* at *A*, making *GA* equal, to scale, the kv.-a. load of the motor-generator set at 80 per cent. power factor. *OA* will now give the resultant kv.-a. load on the system. A vertical dropped from the intersection of *OA* with *XY* will give *OD* equaling 0.935 part of *OY* the power factor of the resultant load *OA*. The resultant kv.-a. *OA*, Fig. 4, is equal to 1835 at 93.5 per cent. power factor and represents the line characteristics due to the addition of the leading power factor motor-generator set. The effect of the addition of any synchronous motor-generator set to a power line may be calculated in a similar manner.

These cases cover practically all the conditions likely to occur in ordinary practice. A problem may be complicated by a combination of these conditions, but it can be quickly and readily solved by the vector addition of the various loads with their right direction and magnitude. Care must be taken, however, that they are combined in their logical sequence as they occur along the line.

The foregoing procedure to solve power-factor problems is simple in operation and has the advantage over any system of tables or curves which may attain similar results in that it graphically represents the line conditions and minimizes the possibility of error.

Royer Flow Indicator

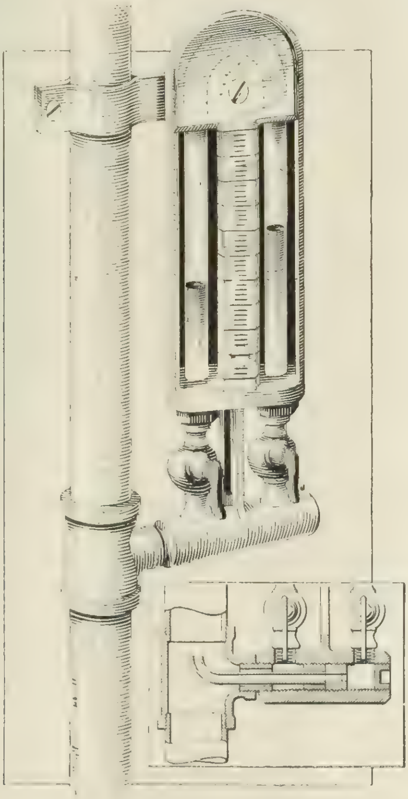
Realizing the need of a simple and inexpensive instrument that will indicate flow in steam, gas, oil, water or air lines and will be used generally in much the same way that a pressure gage is now employed, L. D. Royer, of the Ford Motor Co., has perfected and applied for letters patent on such a meter. He has employed it to such good advantage in the measurement of lubricating oil to the bearings of turbines and reduction gears in the "Eagle" patrol boats built by the company and in the measurement of steam, water and producer gas in the Highland Park plant, that the Sloan-Striker Co., Detroit, has taken over the device for general distribution.

The instrument is a simple adaptation of the pitot tube, with an inverted U-tube measuring the differential between the dynamic and static heads; that is, giving directly the velocity head. Knowing this, it is easy to compute the quantity flowing and prepare a chart covering the range of service in which the meter is to be employed. Such a chart is supplied with the meter, based on the internal diameter of the pipe to which it is to be attached and on the temperature and pressure of the medium to be measured. The scale is divided into tenths and may be calibrated into gallons per minute, cubic feet per minute, pounds per hour, or any unit desired. In the case of gas or steam a second chart is furnished to correct for variations from the temperature or pressure at which the meter is expected to operate.

Reference to the illustration will show that the dynamic, or impact, tube points up. It has one opening and this by means of the 10-point method is located at the mean velocity point. In small pipes where this method would be impractical, the opening is located at the center of the pipe and the proper correction factor applied. The correction is incorporated in the chart. The static tube is concentric with the dynamic tube. With gas, kerosene is used as the measuring fluid, for other mediums, water or mercury, depending upon the velocity. For low velocities the instrument is inverted and the differential read in inches of water. When it is desired to place the instrument on a gageboard or within reading distance from the floor, the nozzle is located at the required point in the pipe line and connection to the meter is made by two small copper tubes.

There has been no attempt to make the instrument universally applicable to all sizes of pipe, as it was desired to avoid complication. It is designed specifically for the diameter of pipe on which it is to be used and for the prevailing conditions of temperature and pressure. It is not intended to replace the recording meter, but may be used to supplement it. The meter should prove valuable in discovering losses originating from leaks or in testing work. It should be useful in the cooling-water line to the condenser, to measure water for the boilers or for manufacturing processes, to divide the steam, water or air services in a plant, to indicate oil flow to a turbine, and a variety of similar uses.

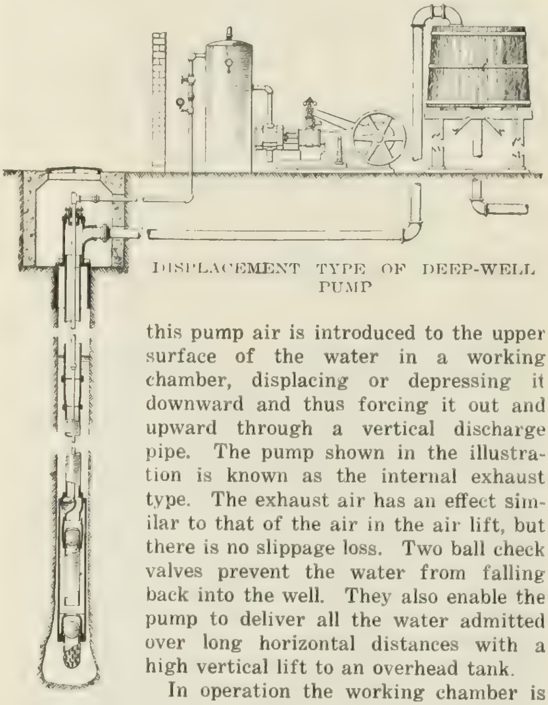
For testing work where different pipe diameters, mediums and conditions would be encountered, a portable instrument has been designed. It is similar to the stationary type, but is provided with tubes of varying length for pipes of different diameter, has universal connections, a leveling adjustment and is packed in a suitable carrying case. Charts are not provided with this instrument, but the necessary formulas and instructions are given for computing the quantity of flow of all of the various mediums previously mentioned.



APPLICATION AND DETAILS OF ROYER FLOW INDICATOR

Weber Subterranean Pump

The Weber subterranean pump, manufactured by the Weber Subterranean Pump Co., 50 E. 42d St., New York City, operates with compressed air, but is not an air lift, the pump being of the displacement type. In this pump air is introduced to the upper surface of the water in a working chamber, displacing or depressing it downward and thus forcing it out and upward through a vertical discharge pipe. The pump shown in the illustration is known as the internal exhaust type. The exhaust air has an effect similar to that of the air in the air lift, but there is no slippage loss. Two ball check valves prevent the water from falling back into the well. They also enable the pump to deliver all the water admitted over long horizontal distances with a high vertical lift to an overhead tank.



DISPLACEMENT TYPE OF DEEP-WELL PUMP

In operation the working chamber is submerged and water is admitted through the lower, or intake, valve. When air is applied, it depresses the liquid level in the intake chamber and displaces all the entrained water until the liquid level is depressed to the level of the discharge outlet. The pressure at this point slightly overbalances the hydrostatic head of the discharge column, and then, by virtue of its buoyancy, the air ascends the discharge pipe and carries a large percentage of water with it. At the same time the air pressure in the chamber drops, due to the sudden discharge, to a point lower than the hydrostatic head in the well, or the head due to submergence. The excess of water pressure partly refills the intake chamber or the filling continues until the air pressure exceeds the water pressure and discharges again take place. In practice these discharges occur so rapidly that the stream shows but the slightest intermission in a well-designed installation.

The intake chamber is from four to ten feet long and the discharge-pipe diameter increases as it approaches the ground level, so that the velocity of the discharge is reduced and part of the extensive energy is recovered, due to the gradually increasing area. The cages and ball valves are made of bronze, the balls are hollow and so balanced that the center of gravity is at the center of the ball. In addition, the balls seat quickly as they are balanced by the water when on the seat.

The drop-tube type of pump, shown in the illustration, is designed for wells that are partly cased or for sand wells in which the casing is frequently not air-tight.

Alignment Charts for Finding the Dimensions and Volumes of Bumped Heads

By C. H. BERRY*

BUMPED or dished heads of boiler drums, tanks and similar vessels, and the bumped or dished heads of pistons, cylinder heads, etc., have three important dimensions: The diameter of the bump or dish, the radius of the spherical surface of the bump, and the height (or depth) of the bump. These three dimensions are related, as will be seen from Fig. 1, and the relation is given by the formula,

$$(R - h)^2 + \frac{d^2}{4} = R^2$$

in which

d = Diameter of the vessel;
h = Height of the bump;
R = Radius of the spherical surface.

From further inspection of Fig. 1 it will be evident that for given values of d and R there are two possible values of h, one of these corresponding to the smaller segment of the sphere, the other to the larger segment. In the case of bumped heads we are concerned only with the smaller of these two segments; that is, the one which is less than half of the sphere of which it is a part. The volume of such a portion of a sphere is given by the formula,

$$V = \pi h^2\left(R - \frac{h}{3}\right)$$

in which V represents the volume and the other symbols have the same meaning as before. The values of d, h and R must be expressed in the same units—either inches or feet—and the volume V will then be found in either cubic inches or cubic feet.

To reduce the labor of computation, the accompanying alignment charts may be used to secure the results with a degree of accuracy sufficient for most practical applications. The limitations of such computations should be borne in mind. All the quantities involved are subject to errors of measurement; the bump may not be a perfectly spherical surface; and, there is usually a round corner or fillet at the junction of the bumped head with the cylindrical portion of the vessel. There is no simple means of correcting for the volume of this fillet, and unless its radius is unusually large, it can safely be neglected in most practical work. In view of these limitations it is probable that the charts will give the desired results to as great a degree of accuracy as is consistent with the information available.

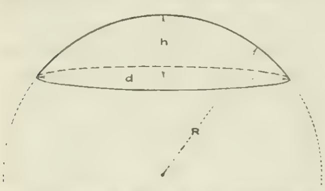


FIG. 1. DIMENSIONS OF SEGMENT OF SPHERE

The chart shown in Fig. 2 gives the relation of the three dimensions R, h and d of a bumped head, any one of which may be found from the chart if the other two are known. For example, suppose that in a certain bumped head the diameter d of the segment is 34.6 in. and the height h is 10 in. Locate 34.6 on the right-hand scale and 10 on the diagonal scale and through these two points draw a straight line, continuing it to the left-hand scale, which it will cut at 20. Then 20 in. is the radius R of the spherical surface.

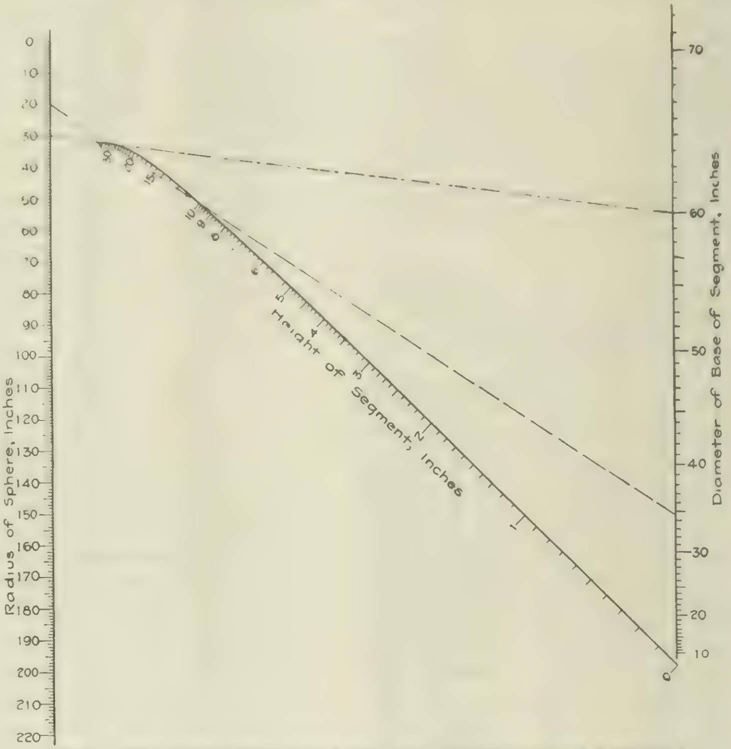


FIG. 2. CHART SHOWING RELATION OF DIMENSIONS OF SEGMENT OF SPHERE

If the values of R and d are assumed—as 20 in. and 34.6 in., for example—the point 20 is located on the left-hand scale and the point 34.6 on the right-hand scale and the two are joined by a straight line as shown. This line will cut the diagonal at two points, at which the values 10 and 30 will be found, indicating that the height of the segment has two values; namely, 10 in. and 30 in. There is nothing strange in this, for 10 in. represents the height of the smaller segment and 30 in. the height of the larger segment, or the remainder of the sphere. Further, the sum of these two values must equal the diameter of the sphere, that is, must equal twice the radius of the sphere, and in the example given, 30 + 10 = 40 = 2 × 20. As a further

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example suppose that R equals 30 in. and d equals 60 in. Then there is only one value of h apparent on the chart; namely, 30 in. In this case, the bump is exactly half of the sphere, so that the two segments both have the same height, which equals the radius of the sphere.

After the radius of the spherical surface and the height of the segment have been determined, the volume of the bumped head may easily be found by using the chart shown in Fig. 3. On the right-hand scale is located the value of the radius of the sphere and on the diagonal the value corresponding to the height of the segment, and through the two points a straight line is drawn and continued to the scale at the left, which it will cut at a point indicating the volume of the bump.

Suppose, for example, that a bumped head has a radius of curvature of 48 in. and that the height of the segment is 12 in. and let it be required to find the volume. On the right-hand scale locate the value 48 and on the diagonal the value 12 and through these two points draw a straight line, continuing it to the left until it strikes the left-hand scale. The point at which it cuts the left-hand scale corresponds to 20,500 cu.in., which is the volume of the bump.

In the chart in Fig. 3 it should be noted that for given values of R and h there is only one value of the volume, V. This is as it should be, since for given values of R and h there is only one possible segment of a sphere. It will be further noted that for given values of R and V—as, for example, 11.7 in. and 4700 cu.in. (2.7 cu.ft.) respectively—there may be two values of the height h; namely, 15 in. and 30 in. Further examination of these values will show that the larger is impossible. In the example it is obviously impossible to have a segment of radius 11.7 in. which has a height of 30 in. since this height is greater than the diameter (twice the radius) of the sphere. This apparent double value of h arises from the mathematical form of the expression for the volume. The larger value is what the mathematician would term an imaginary quantity which for practical purposes has no significance.

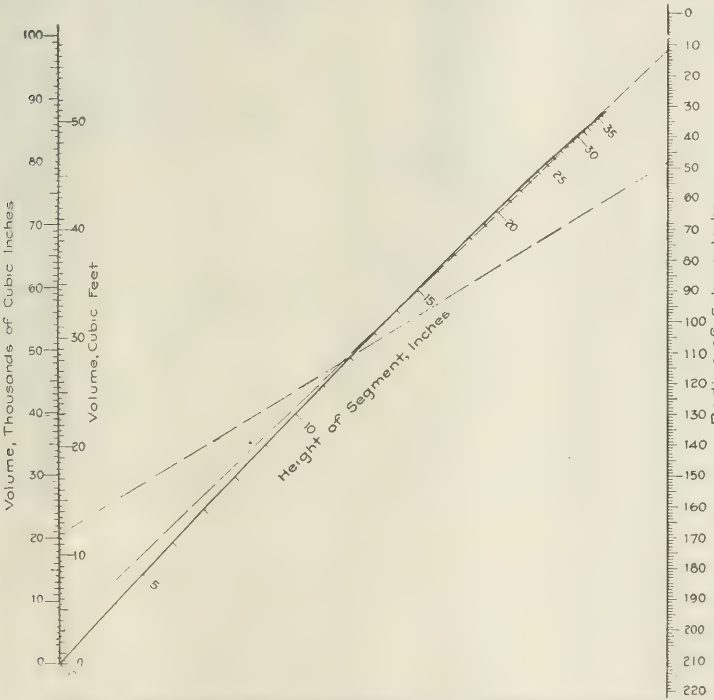


FIG. 3 CHART FOR FINDING VOLUME OF SEGMENT OF SPHERE

The charts may be used for the solution of problems in either direction. That is, it is easy to find the volume of a bumped head of given dimensions, or to find the dimensions of a bumped head of given volume. If the radius of the spherical surface of the bump is unknown, the height and diameter can be measured and the radius found from Fig. 2. Since there is usually a round corner at the base of the bump, it is necessary to determine the radius of the sphere from measurements taken entirely on the spherical surface, as shown in Fig. 4, using two steel scales. Radius r is half of the diameter of the portion of the bump measured, and the distance h is the height of the same portion. Doubling r gives the diameter to be used in the chart, Fig. 2, together with the height h. In finding the volume, use the actual total height of the entire bump, and not the smaller height measured in this way for the determination of the radius of the sphere. It is well to remember that the volume desired is usually the inside volume of the head, so that the thickness of the metal should be deducted from the value of R when the measurements are taken as shown in Fig. 4.

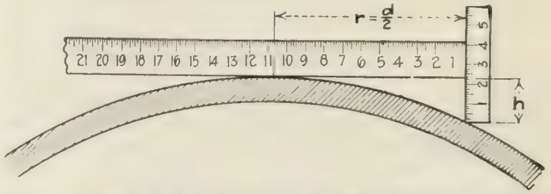


FIG. 4 OUTSIDE MEASUREMENTS FOR FINDING RADIUS OF CURVATURE OF BUMPED HEAD

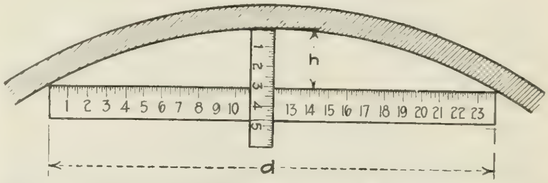


FIG. 5. INSIDE MEASUREMENTS FOR FINDING RADIUS OF CURVATURE OF BUMPED HEAD

If the inside of the head is accessible, the measurements can be taken as shown in Fig. 5, and used in the same way. In the methods of both Fig. 4 and Fig. 5 it is not necessary that the steel scales be held perpendicular to the center line of the cylindrical portion of the vessel, so long as all the points of contact are on the spherical portion of the bump. The charts are designed for use in connection with the bumped or dished heads of drums and tanks and will not give satisfactory results in figuring the dimensions or volumes of small bumps, such as pistons or cylinder heads of small internal-combustion engines.

Preparing Coal Samples for Analysis

THE STATE institutions of Illinois bought coal on the B.t.u. basis previous to the war. It was tested in the chemical laboratory of the University of Illinois and for eighteen institutions a saving in the fuel bill of $20,000 per year was effected at an expense for testing of $1500. Buying coal on specification will be resumed after July 1 of the present year, and the University will test the samples as in the past.

Fine coal that will run through a ¼-in. screen has twice as much ash as lump coal, and as the fine coal and dust segregate it is a delicate matter to take a good representative sample. A definite system insuring uniformity is desirable, and generally it proves more satisfactory to eliminate as much as possible the human element. With these thoughts in view Prof. S. W. Parr, of the University of Illinois, distributed at a recent meeting of the chief engineers of Illinois state institutions at Dunning a set of instructions directing how the samples might best be taken. The instructions are thorough and should be of benefit to all plants buying coal on the same basis. For this reason they are presented herewith. Illustrations of the different kinds of equipment required are shown in Fig. 1.

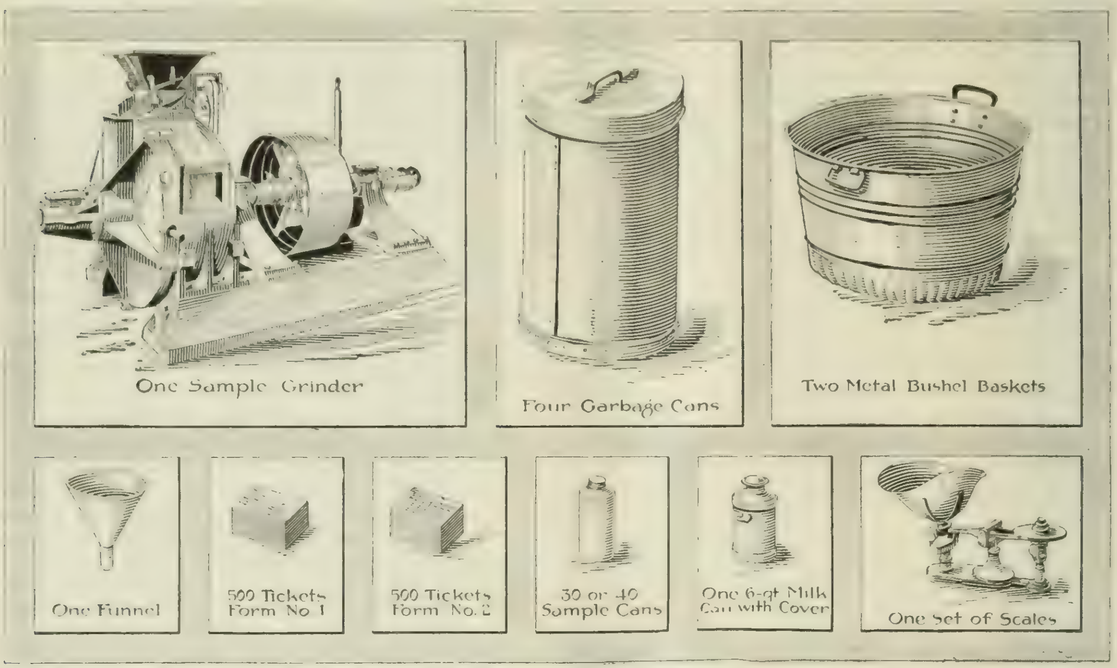


FIG. 1. ILLUSTRATIONS OF THE EQUIPMENT REQUIRED FOR COAL SAMPLING

SCREENINGS AND SLACK COAL

The gross samples (for use with the Sturtevant automatic sample grinder) shall be taken in two divisions, each of approximately 200 lb., making 400 lb. in all. These samples shall be taken from the car in the process of unloading and shall be placed in a clean receptacle, such as a garbage can with a tightly fitting lid. To obtain each sample of approximately 200 lb., about one-half shovelful in every ten should be thrown into the receptacle. The samples are best selected by shoveling from the bottom of the car, because the top coal rolls down and mixes with the bottom coal in a fairly even manner. Great care, however, should be taken to select the proper proportions of coarse and fine coal from top to bottom and lengthwise of the entire mass. Where practicable, the two receptacles should be placed for filling, one on either side of the car. In the process of unloading they should be moved along the entire length of the car in order to insure the collection of the sample from all parts of the load.

It should be noted that dust determinations are not necessary on run-of-mine and lump coal. For obtaining the percentage of dust in screenings or slack, one of the 200-lb. samples should be thoroughly mixed by shoveling, as in the manner of mixing concrete. It shall then be spread out evenly on a concrete floor and quartered with a straight-edge.

One-quarter (about 50 lb.) shall be selected and placed in a weighed bushel basket and the weight of the coal carefully recorded on the ticket accompanying the sample. It shall then be passed through a ¼-in. screen into a second weighed basket and the weight of the material passing through shall be noted on the ticket. Do not mix again with the main sample, but reject the entire quarter after screening these factors for determining the percentage of dust.

The remaining three-quarters of the sample shall be combined with the other division of 200 lb., making a total weight of the combined lots of approximately 350 lb., and this gross amount without further mixing is run through the sample grinder. The sample obtained from the mill, which will now be about 35 lb., shall be again put through the mill, which will deliver a sample of about 3.5 lb. The mill should be set to deliver material ground to pass through a sieve of ¼-in. mesh.

Collect this last sample of three or four pounds directly in one of the shipping cans, using the large funnel to avoid loss. Put in a ticket having the date, car number, net weight of coal in the car and the dust factors; that is, the net weight of the quarter taken and the net weight of the dust. This ticket, known as Form No. 1, is shown in Fig. 2. Screw the cap firmly in place and retain in a cool room until the requisite number for composition has been taken. Wrap electrician's tape around the skirt of the cap to guard against moisture loss.

From (Name of institution) Date 19 (When taken)
Kind of coal
Car initials Car No
Net weight
Weight taken for composite*
Weight of quarter taken for dust
Weight of dust in quarter taken

* Divide the net weight by 2 and place a decimal point after the first figure of the quotient.

From (Name of institution) Date 19 (When composited)
Kind of coal

FIG. 2. FORM NUMBER ONE

When ten of the small samples have been collected (or five where composites are made up of five carloads) proceed as follows:

Divide the net weight of coal in the load, as shown on the ticket, by 2, place a decimal point after the first figure of the quotient, and the result will represent the number of pounds and tenths of a pound to be taken from the can. Example: Net weight of coal = 50,000 lb.; 50,000 ÷ 2 = 25,000; and pointing off as directed gives 2.5. Therefore, 2.5 lb. is taken for the composite.

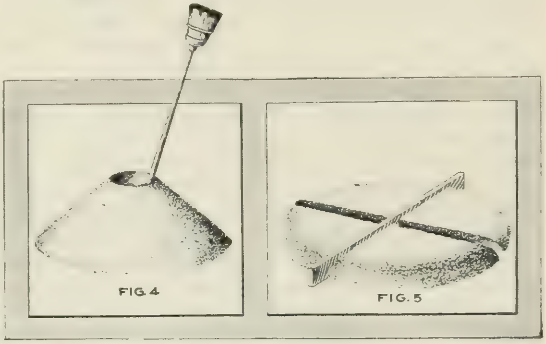
Date of Unloading	Car Initials	Car Number	Weight Taken for Composite, Pounds	Weight of Quarter Taken for Dust, Pounds	Weight of Dust in Quarter Pounds

FIG. 3 FORM NUMBER TWO

Take the several cans in order and empty the first one entirely into a 6-qt. milk can having the usual rounded top and telescoping lid. Put on the lid and shake well by turning the can completely over at least ten times, and weighing into the counterpoised scoop or pan of a scales, the weight used being found from the division by 2, as previously directed. Weigh to the nearest tenth and empty the scoop into a metal bushel basket. Continue in like manner for each one of the ten, or five, cans.

The metal basket will now hold the gross composite in the proper proportion from each car, and should consist of from 30 to 40 lb., or proportionately less if five cars are being sampled. After thoroughly cleaning the sample grinder, pass the gross composite through the mill (previous mixing is not necessary) and collect the sample directly in one of the cans. Fill out a ticket like that shown in Fig. 3, known as Form No. 2, and put it in the can; screw on the cover and wrap the base of the screw cap with electrician's tape as a further precaution against loss of moisture. The final sample should then be sent at once to the laboratory.

For duplicate samples to be retained, pass the gross composite a second or third time through the sample grinder and collect the small samples directly in a can. Add a ticket that will show the date, car number, etc. Seal as in the case of the first can and retain until after settlement.



FIGS. 4 AND 5. FLATTENING THE HEAP OF COAL AND THEN QUARTERING THE PILE

The gross sample (for use with the Sturtevant automatic sample grinder) shall be 400 lb. For convenience in handling it may be taken in lots of 200 lb. each.

The greatest care should be taken to get a correct proportion of coarse and fine coal. To obtain an even distribution of coarse and fine coal, it is necessary to select portions from all parts of the car. Do not pick out the bright pieces of coal. Do not select pieces of slate or stony material that are not distributed throughout the car in the same proportion as it occurs in the 400-lb. sample.

The 400-lb. sample shall be put through the sample grinder immediately. The resulting 40-lb. sample shall be again run through the mill and the 4-lb. sample placed in the sample can with the ticket correctly filled out, giving date, net weight of car of coal, car number and initials. The lid shall be firmly screwed on and sealed with electrician's tape. The sample shall be retained until the proper number for the composite is obtained.

For the composite, follow the same directions as were given for screenings and slack coal. It should be noted, however, that if five cans are used they will give a gross composite of only 15 or 20 lb., and on passing this through the sample grinder once a sample of 1.5 to 2 lb. will result. It is directed, therefore, that the gross composite of 15 to 20 lb. be passed through the mill twice, collecting in the same shipping can the sample delivered from each of the two grindings. Add the tickets with the necessary data, seal and ship as directed. It is not necessary to determine the percentage of dust in run-of-mine samples or lump coal. Duplicate samples to be retained for reference should be obtained by passing through the grinder until the proper amount has been collected. If it is desired to make a composite of ten samples of coal, the procedure given for screenings and slack coal shall be followed.

RUN-OF-MINE AND DOMESTIC LUMP COAL SAMPLES WITHOUT SAMPLE GRINDER

It is always recommended that a sample grinder be used when possible, but when such equipment is not available the following procedure is recommended: The gross sample shall weigh 400 lb. For convenience in handling, it may be taken in lots of 200 lb. each. The greatest care should be taken to get a correct proportion of coarse and fine coal. To obtain an even distribution of coarse and fine coal it is necessary to select portions from all parts of the car. Do not pick out the bright pieces of coal. Do not select pieces of slate or stony material which are not distributed throughout the car in the same proportion as it occurs in the 400-lb. sample.

The sample of 400 lb. is placed on a clean concrete platform about 15 ft. in diameter. This platform should be protected from rain and sun. Do not use a warm boiler-room floor. The coal is spread out and quickly reduced with a tamper to 1-in. size. Retain all the sample on the sampling platform. It is next mixed thoroughly as in mixing concrete and then collected into a cone-shaped pile by shoveling the coal from the outer margin of the pile onto the center of the heap. In this way the coarse and fine pieces are evenly distributed.

A broom handle is then inserted into the cone from the top to the floor and by holding the broom at a sharp angle to the floor a circle is described in the coal, as shown in Fig. 4, gradually working to the outer edge of the pile. By this means the coal is spread out evenly into a circular pile about 6 in. deep. With a board or straight-edge the pile is divided at right angles through the middle into quarters, as shown in Fig. 5.

Opposite quarters are rejected, being careful that this includes the dust that cannot be taken up with a shovel. This dust should be swept away with a broom. This operation of mixing, coning and quartering shall be repeated two times, which will reduce the sample to about 50 lb. At this point the sample shall be tamped to ¼-in. size. It shall again be thoroughly mixed and quartered and opposite quarters rejected until a sample of about 8 lb. is obtained. This shall be mixed and divided into two parts, each being immediately placed in a sample can along with a ticket of Form No. 1 showing the date, car number, car initials and net weight of coal. The tops of the cans are screwed on and sealed with electrician's tape and one sample mailed to the laboratory, the other sample being saved for reference. If a composite is to be made, it is necessary to retain but one 4-lb. sample.

A gross sample of 400 lb. shall be taken in exactly the same way as described for use with the Sturtevant automatic grinder. After 50 lb. of the sample has been taken out for determining the percentage of duff, the remaining 350 lb. is tamped and quartered down to two 4-lb. samples, as described in taking samples of run-of-mine coal. If a duff sample is not to be taken, the entire 400 lb. is treated exactly as directed for preparing samples of run-of-mine coal.

American Engineering Standards Association

A statement issued by the association outlining the scope of its proposed activities and stating its reasons why such an association is necessary.

IN MANY lines of engineering much excellent standardization work had been done before the war; the war emphasized its importance and showed clearly the need of coöperation to prevent the confusion caused by the promulgation of overlapping standards by independent bodies. During the war the Government Departments coördinated these efforts in certain lines and greatly assisted in unifying them. The American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers and American Society for Testing Materials, recognizing the value of what had been done, invited the Government Departments of War, Navy and Commerce to appoint representatives to act with them to continue this work. The body so formed is the American Engineering Standards Committee. It has required considerable time to definitely formulate its objects, and to arrange methods for accomplishing them that would be effective without in any way interfering with the many organizations that have been doing such excellent work in this line.

The American Engineering Standards Committee has just completed and adopted a revision of its Constitution which has been sent to the Governing Boards of all the Departments and societies represented on the committee with a request for its ratification.

The new Constitution changes the name to American Engineering Standards Association, the change from "Committee" to "Association" more fittingly indicating the wide scope of the interests involved.

The objects of the Association are stated as follows:

1. To unify and simplify the methods of arriving at engineering standards, to secure coöperation between various organizations and to prevent duplication of standardization work;
2. To promulgate rules for the development and adoption of standards;
3. To receive and pass upon recommendations for standards submitted as provided in the Rules of Procedure, but not to initiate, define or develop the details of any particular standard;
4. To act as a means of intercommunication between organizations and individuals interested in the problems of standardization;
5. To give an international status to approved American engineering standards;
6. To coöperate with similar organizations in other countries and to promote international standardization.

Means are provided for increasing the number of representatives in the Association by invitation or on request. Several important organizations interested in standardization will be invited to appoint representatives as soon as the necessary power is obtained.

The routine work of the Association will be conducted by its Secretary under the direction of a Board of Directors. This board will have power to deal with all of the affairs of the Association except the final approval of the standards submitted to it.

Any organization may request the Association to approve standards which it has formulated, or to approve committees that it has appointed, and by so doing becomes a Sponsor Society. Such a request is entirely at the option of the organization that has formulated or expects to formulate the standard. At the request of the Sponsor, approval of the standards is given when they are the substantially unanimous conclusions of a committee made up as follows:

(a) Sectional Committees dealing with standards of a commercial character (specifications, shop practices, etc.), shall be made up of representatives of producers, consumers and general interests, no one of these interests to form a majority. General interests include independent engineers, educators, and persons who are neither consumers nor producers.

(b) Sectional Committees dealing with standards of a scientific or non-commercial character shall consist of persons specially qualified, without regard to their affiliations.

It is anticipated that in nearly all cases the approval of standards and committees by the Association will be requested. In case it is considered advisable, the Association is authorized to call a meeting of those who would be interested in the formulation of a new standard or the revision of an old one, to select one or more Sponsor Societies. The Sponsor Society or Societies will appoint a Sectional Committee to formulate or revise the standard. This Sectional Committee will report to the Sponsor when its work is completed. The Sponsor may then request the Association to approve. The Association deals only with the Sponsor and acts only at its request. Provision is made in all publications that a standard must be referred to as that of the Sponsor, using whatever title the Sponsor has given it, followed by the statement "approved by the American Engineering Standards Association." The approval may be given in one of three ways as—Recommended Practice, Tentative Standard, or Standard, the expectation being that nothing will be approved as Standard until it has shown that it is generally acceptable.

The Association thus acts only to bring together those interested in a common object, and when they have completed their work, will at their request, certify that it has been done in such a manner as to justify its adoption. Nothing revolutionary is proposed, it is merely an extension of present practice. The Executive Committee of the American Society for Testing Materials now passes on the composition of committees, ascertains that their conclusions are substantially unanimous, and, if so, reports them to the society for acceptance or rejection. The Association does the same for groups of organizations. Its Board of Directors performs the same functions as the Executive Committee of the American Society for Testing Materials, and the Association as a whole accepts or rejects. It neither selects Sponsors nor Sectional Committees; it does not consider the subject matter of a standard, nor the procedure under which it is arrived at, except that it requires sufficient information from the Sponsor to show that the conclusions are substantially unanimous and that the Sectional Committee is balanced and representative. It requires that in all publications the Sponsor shall be given full credit.

In addition to this work in assisting in the selection of committees and certifying that their work has been done under proper conditions, the Association will act as a bureau of information regarding standardization. It will collect information regarding existing standards and as to the bodies that have formulated and adopted them. This will enable it to promptly give necessary information to those who select a committee to formulate a new standard or revise an old one. It will also enable it to furnish information desired by the working committees regarding what has been or is being done on similar or related lines. It will establish relations with similar bodies in other countries and can do much to promote the acceptance of International Standards. It is possible to secure international acceptance of American Standards more easily through such a body than in any other way.

WILL AVOID DUPLICATION OF WORK

With these fundamental restrictions of its activities it may be asked whether there is sufficient reason for the existence of the Association. This naturally has been carefully considered and it is the unanimous conclusion of the committee and of all of those who have been consulted who have been active in standardization work, that such an organization is urgently needed. In the past there have been many occasions when two or more organizations have formulated standards for substantially the same thing. Ofter these differences have been very slight, but neither has been quite acceptable to the other party. In the majority of such cases if these organizations had been brought together at the start they could have agreed on a standard that would have been satisfactory to both. The American Engineering Standards Association will furnish a means by which any organization intending to define a standard can readily acertain what others are interested, and should be consulted in regard to it. At present there is no such means. There is nowhere anything approaching a complete list of the organizations doing standardization work, much less any list of the standards proposed or in preparation. The enormous advantage of having any standard generally accepted, and the much greater probability of accomplishing this if it is prepared under definite conditions that have proved effective in the past, will, it is believed, cause most of the organizations engaged in such work to ask and receive the assistance of the American Engineering Standards Association. It provides definite machinery for securing co-operation and preventing duplication of work. It establishes definite rules securing the absolute autonomy of any group engaged in the development of standards and insures that this group shall receive full credit for its work.

With the assurances of coöperation that the American Engineering Standards Committee has already received, we believe that there is no question of the advisability of forming the more broadly representative Association. Several organizations have already presented requests for the approval of existing standards and we are informed that many others only await the notification of the Committee that it is fully organized.

It has been impossible to make any public statement of the Committee's plans until they had been definitely formulated. This, we feel, has now been accomplished.

Care of Heating and Ventilating Equipment

By HAROLD L. ALT

Gravity hot-water heating systems are discussed. Tells of troubles caused by two small pipe lines and with radiators getting either too much water or too little. Several methods of controlling the flow of water to the radiators are taken up.

THERE are a large number of hot-water heating systems in use at the present time, although they are not as numerous as steam systems. The operating engineer, being required to operate the equipment found in the building, must be familiar with the general principles governing its operation or some day he will run up against a proposition that will be too much for him. With properly designed gravity hot-water systems little attention is required in operation. If the pipes are too small, the trouble is fundamental, but other difficulties, more frequently met with, consist of some radiators getting too much flow and others not enough.

It is a law of hot-water circulation that the higher the riser the more rapid will be the movement of water therein and the larger the amount of radiation that may be supplied from a riser of a given size. This rule holds for a building of ordinary height, say up to six or eight stories. Just how much this increase can be made, in actual practice, is a subject on which there is considerable difference of opinion, and in fact, tables of pipe-riser capacities for buildings over three stories high are exceedingly rare. Extending one of the best "three-story" tables to include eight stories makes the riser capacities as follows:

SIZE OF PIPE

Story	¾-In.	1-In.	1¼-In.	1½-In.	2-In.
	Square Feet of Radiation				
Basement ceiling	40	70	110	180	300
First	50	80	117	195	375
Second	60	90	135	210	450
Third	70	100	147	230	500
Fourth	80	110	170	245	575
Fifth	90	120	187	260	650
Sixth	100	130	205	275	700
Seventh	110	140	222	295	775
Eighth	120	150	240	310	850

One job was put in with pipe sizes as shown in the table and it worked perfectly, the only question being whether the risers of increased height could not possibly be reduced still farther.

There are several methods of controlling the flow of water to a radiator, the simplest, although somewhat expensive, way being to place a lock shield valve on the return end of each radiator so as to restrict the circulation in the favored radiators and to force the water into the less-favored ones, Fig. 5. The reason water does not flow through a given radiator is that the friction is excessive and the flow takes the easier path through the lines where the resistance is less. Therefore, if the resistance is increased in the easier-flowing lines until it equals that in the less-favored pipes, there will be an equal flow in all the lines. Of course, if the circulating pipe is too small for the work it is intended to do, there is little gained in closing down the other radiators, for the resistance of the system will then build up to such an extent that the circulation will be disturbed if not entirely stopped. There are other methods of controlling the flow to hot-water radiators, such as the use of a distributing fitting like that illustrated in Fig. 1, or making the riser connection in the manner shown in Fig. 2, arranging the connection so that the radiator with the sluggish circulation is taken off at the top of the tee and the radiator getting too much water is connected to the side; and since hot water always tends to rise, it will favor the higher connection. This is forcibly illustrated in cases where radiators are tapped directly off the horizontal main and not off a riser. Therefore the radiators at the farther end of the line, which would normally have a poor flow (owing to the added friction of the increased length of run), should be taken off the top of the main whenever possible, as shown in Fig. 3, and those nearest the boiler should be tapped off the side of the main, as shown in Fig. 4, because these radiators will circulate without trouble. For radiators set in an intermediate position between the nearest and farthest ones, a connection such as shown in Fig. 5 will be the right one to use. In fact, any radiator will have its circulation assisted by being connected to the top of the main or hindered by being connected to the side or bottom. A gravity hot-water system will be helped in its circulation by the use of some of the so-called "accelerators," of which there are many on the market. They operate on a somewhat contradictory principle of introducing a certain amount of resistance,

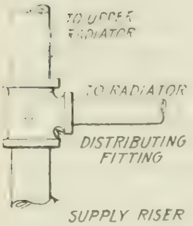


FIG. 1. DISTRIBUTING FITTING

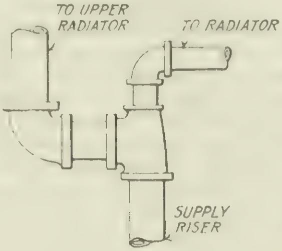


FIG. 2. RISER CONNECTION

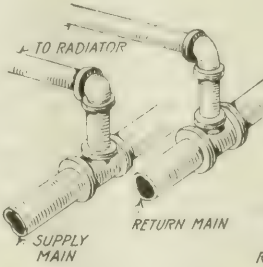


FIG. 3. RADIATORS CONNECTED TO TOP OF MAIN

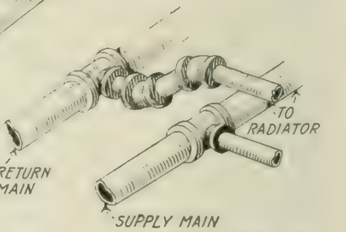


FIG. 4. RADIATORS CONNECTED TO SIDE OF MAIN

thereby increasing the pressure and consequently the temperature to which the water can be heated without having it boil. This temperature rise is often sufficient to cause a good circulation in a poorly designed plant, since the water movement is dependent on the difference in temperature of the water in supply and return lines.

Gravity hot-water heating systems are two-pipe, upfeed or downfeed. There have been a few so called one-pipe systems installed where a single main is used. The hot supply water is supposed to flow along the upper part of this pipe and is tapped off at the top, while the return water flows in the opposite direction in the lower part of the pipe. This system, however, is not a good one to use.

With the two-pipe system an upfeed may be used as illustrated in Fig. 7 or a downfeed arrangement as shown in Fig. 8. The downfeed circulation is undoubtedly superior to the upfeed, but is slightly more expensive and attic space for the supply main is necessary. No gravity system will circulate if there are high points in which the air is allowed to collect. For this reason all radiators on an upfeed system must have air-vent valves because the tops of the radiators constitute high points on the line. On the other hand, in the downfeed system, if top inlet radiators are used, all the air will collect in the supply main because this forms the highest part of the system; but if bottom inlet radiators are used, they form additional high points and must be vented, as in the case of the upfeed system. To avoid air troubles in the piping the slope of the lines should be continuously upward to the highest point, where there should be an air vent, and then continuously downward to the lowest point in the piping. Dips and pockets must be avoided.

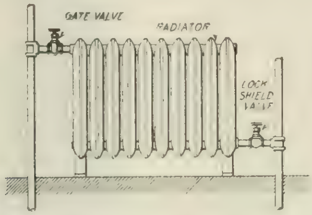


FIG. 5. INTERMEDIATE RADIATOR AND VALVES

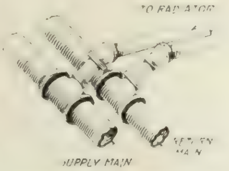


FIG. 6. SHOWING PIPE CONNECTION

Another fact that must not be forgotten is that water expands and contracts with a variation of the temperature; so that some provision for this expansion must be made in every system. The most common method of caring for this is to place a small tank at the highest part of the system so that the water in the system can back up through the "expansion pipe" (which is run from the bottom of the tank down to, and is connected with, the main return line) and into the tank when it is heated and expanded, and when the water in the system is cooled the water stored in the tank will flow back into the system and make up for the contraction of the cooling water. Such tanks are usually provided with a fresh-water supply governed by a ball-cock and also have an unrestricted overflow to take care of any surplus water that may be in the system from any cause. The expansion tank should be large enough to accommodate the increase and decrease in the volume of water contained in the system due to the expansion and contraction caused by heating and cooling the liquid. This cubic capacity may be approximated by the formula, $C = \frac{R}{40}$, in which C is the capacity of tank in gallons and R the amount of radiator surface in the system.

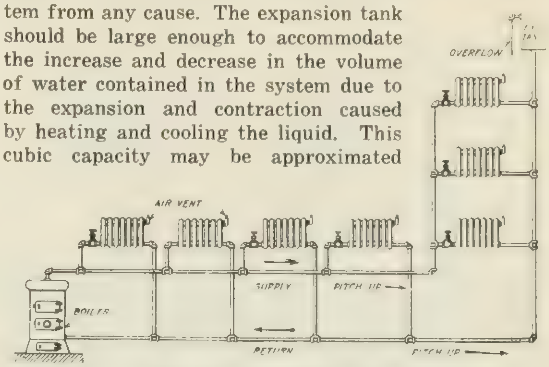


FIG. 7. TWO-PIPE UP-FEED ARRANGEMENT

This formula is developed on the assumptions that a square foot of radiating surface holds approximately one pint of water, that the piping for a hot-water system usually contains an amount of water equal to that in the radiator, or about half of the water in the system, and that water heated from 32 to 212 deg. increases about one-twentieth in its volume. Therefore every square foot of radiation has one pint of water and the piping contains another, making two pints, and the capacity of the expansion tank is usually taken as double the computed expansion to be cared for. It follows that the tank capacity is really based on four pints capacity per square foot of radiation. If the water expands one-twentieth of its volume, the cubical contents of the expansion tank will be one-twentieth of four pints, or one-fifth pint, for each square foot of radiation; and as there are eight pints to a gallon, this is expressed in gallons by $\frac{1}{5} \div 8 = \frac{1}{40}$ gal. per sq.ft., or 1 gal. for each 40 sq.ft. of radiation.

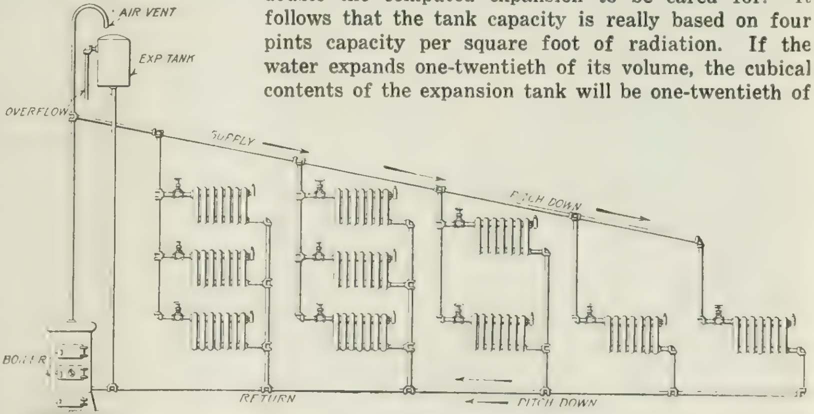


FIG. 8. TWO-PIPE DOWN-FEED ARRANGEMENT

One of the things to be watched for in operating a hot-water system is to avoid having radiators freeze up when shut off. A simple expedient to prevent such trouble consists of drilling a small hole about one-eighth inch in diameter in the wedge or disk of the control valve so as to permit the circulation of a little water through the radiator even when the valve is closed.

Suspension and Concrete Setting of Boilers at the Robert Gair Plant, Brooklyn

A boiler room is made in a concrete building several years old, with a 600-ton coal bunker above the boilers. The boiler settings are of cinder concrete with firebrick lining in the furnace. The boiler and bunker support columns, subjected to the heat of the furnace, are of reinforced concrete.

THE engineers of this company, which owns and operates that interesting group of concrete buildings near the Brooklyn end of the old bridge, excited interest some years ago by the use of cinder concrete (1 cement, 5 cinder, no sand) for boiler settings, going so far as to use no firebrick lining for the hand-fired furnaces. Now comes another interesting setting for new boilers, and designed by the Gair engineers.

As shown in Figs. 1 and 2, the boilers are of the return-tubular (Dillon) type, each 90 in. diameter, 18 ft. long, the weight of each empty, without breeching or steam pipes, being 43,000 lb.; with water at the usual level the total weight of each is 71,300 pounds.

An unusual feature of the setting is that the building columns, also the boiler-support columns, are practically in the furnaces and will be exposed to the temperatures therein. Reference to Fig. 1 shows that the columns for supporting the boilers are each made up of an 8-in. wrought-iron pipe, four ¾-in. square rods for reinforcement, and concrete, the outside dimensions of each column being 16 x 16 in. There is no air circulation through the pipe, it being filled with concrete. The bunker column and the boiler-support column are side by side and appear as one from the top of the boiler down. These columns are covered on the sides, where they are exposed to the heat, with a 12½-in. brick wall; 4 in. of this is firebrick; air space between the column and the wall is provided. The coal bunker, with capacity for 600 tons, also is supported by these columns. There is one 16 x 16-in. column, made of a 2 : 2½ : 5 mixture of cement, sand and broken stone, on each side and at each end of each boiler. The girder, of 1 : 2 : 4 mixture of the same materials as the columns, stretching across two columns, is 12 x 14 in. The hanger rods for the boilers fasten to 15-in. I-beam plates supported by the 16 x 16-in. column. This is shown well in the front elevation, Fig. 2.

The furnace walls are of cinder concrete to a height of five feet above the floor, lined on the sides with firebrick. The remainder of the walls is made of building brick and firebrick. The space between the rear columns and rear walls, also the rear walls, are lined with cinder concrete (see Figs. 1 and 2). The furnaces will be fired by McKensie stokers.

In this most unusual installation, where a boiler room has been made in a building erected several years

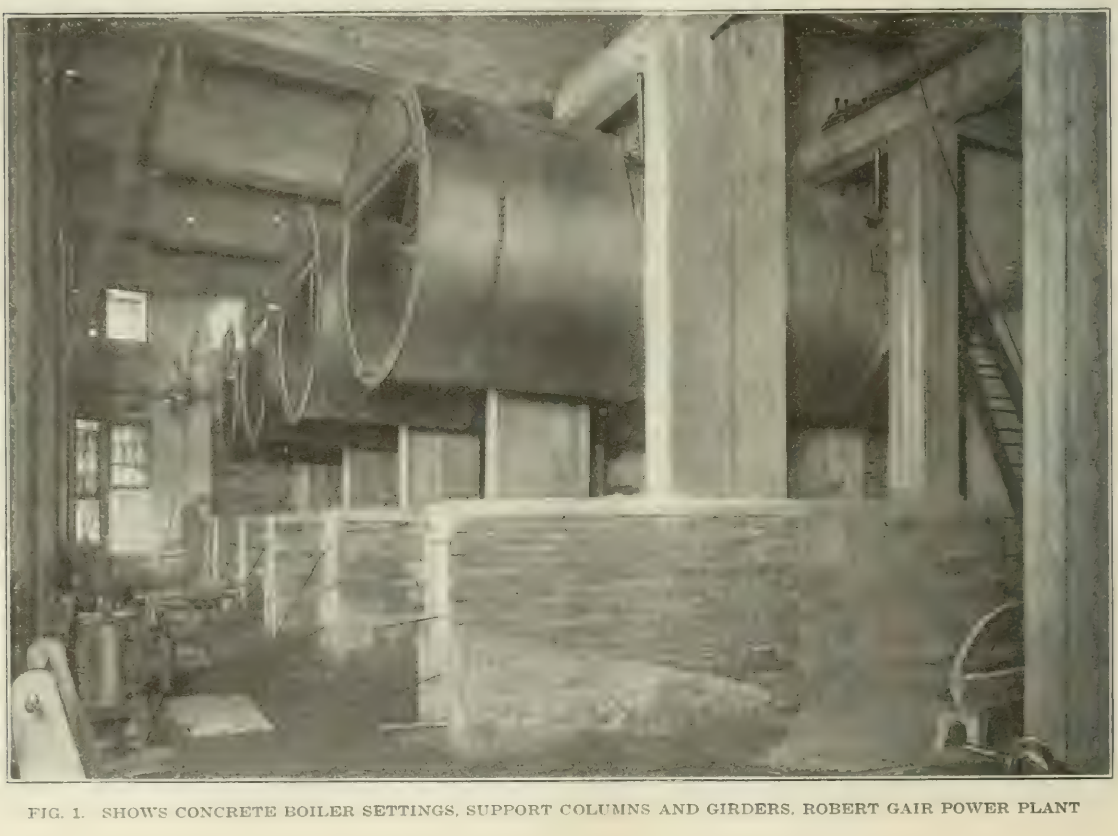
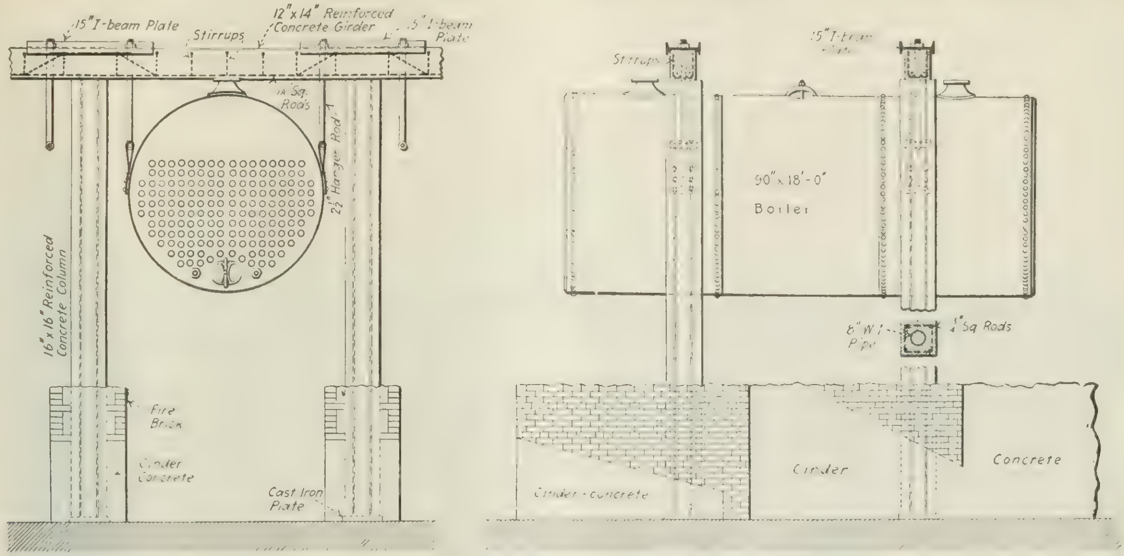


FIG. 1. SHOWS CONCRETE BOILER SETTINGS, SUPPORT COLUMNS AND GIRDERS, ROBERT GAIR POWER PLANT

ago, the load supported by the outer columns shown is 22½ tons (45,000 lb.) per column; the load on the columns between boilers is 45 tons (90,000 lb.) per column. The weight suspended from each girder is 45 tons between supports and 90 tons per boiler, including weight of flues, which rest on top of the girders. The weight of the coal stored in the 600-ton bunker is roughly 52.5 lb. per cu.ft., or 38 cu.ft. per ton. The floor of the boiler room is of reinforced concrete, 5 in. thick, giving 12 ft. headroom from the basement floor.



FRONT ELEVATION SIDE ELEVATION

FIG. 2 CONCRETE BOILER SETTING OF UNUSUAL INTEREST, ROBERT GAIR POWER PLANT

Water Injection in Semi-Diesel Engines

By H. F. SHEPHERD

Some of the old theories as to the action of water injected into the cylinders of semi-Diesel engines are exploded and the advantages and disadvantages of the practice are discussed

CONSIDERABLE discussion has arisen over the use or non-use of water injection in semi-Diesel engines. The various arguments advanced, together with the writer's conclusions after ten years of careful observation in the design and operation of both types, may be summed up in the following statements: The chemical theory that the water injected will dissociate at the high temperature of combustion and its nascent oxygen will combine with and consume all free carbon is not strictly true. A badly designed water-injection engine will carbon. A well-designed engine of either type will not. Some such action may occur, but it is not essential. In the absence of other temperature control, water feed will serve the same end and that is its main function.

It is sometimes urged that water feed will reduce the high-pressure end of the cycle in the production of superheated steam that will expand, delivering the power at a more favorable crank angle. This is a pretty mechanical theory but bad thermodynamics. Each pound of water evaporated during combustion will absorb as latent heat the energy of, roughly, half a pound of oil and in that state the heat is beyond redemption for work during the cycle.

Properly, the water fed must all be absorbed during the scavenging period, taking its heat from the mixed charge and the walls of the cylinder, piston head and vaporizer. This heat would normally go to the jackets. It is readily accounted for in the low jacket loss and high exhaust loss of the water-injection engine, the total of both losses being equal for well-designed and otherwise similar engines of either type, the fuel economies being similar as well. Careful indicator work will check proper construction in this detail. The compression line of the full-load card with full water feed should superimpose on that of the no-load card with no water feed. If lower, liquid is present during compression, its latent heat absorbing the adiabatic heat of that operation. It should be clearly understood that the quantity of water necessary to operation may be controlled by design so as to meet the foregoing condition, in which event it is not possible to feed a harmful excess without a shutdown due to overcooling.

It is urged that water feed will destroy lubrication and will combine with the sulphur in the fuel to produce sulphurous acid, which will work destruction. These are possibilities easily realized with bad design. If the water is thoroughly carbureted or atomized into the entering stream of air and if it is at once vaporized by contact with hot gases and hot metals, it passes through the cycle as steam and is no more harmful than steam mechanically; nor can it form an active acid except in the exhaust pipe after condensation. If it is badly handled or if the engine requires an excessive amount of water, and most certainly if the water is introduced through a drilled port in the cylinder bore, opened and sealed by piston travel, there will be damage.

Some designers claim to use water to control the time of ignition, and it is necessary to that end with engines of bad design. The firing time should be under control of the fuel-injection apparatus. Water should not be used to damp out dangerous premature explosions. If well designed, the engine will require most water with heavy, slow-burning fuels, owing to the greater heating of the walls under after-burning. If badly designed, a great excess of water may be required to prevent the lighter fuels of low flash from causing violent premature explosions. This latter condition arises with injection apparatus that is structurally incapable of delivering the fuel over a sufficiently short angle—not more than 30 deg. and preferably as short as 15 deg. of crank travel—or one in which the delivery, due to air or elastic action of fluid or tubing, is not coincident with the mechanical movement of the fuel pump. These elastic displacements are small, but so also is the fuel charge, especially with small engines at light loads.

The same conditions may also arise due to "lay-overs" of unconsumed liquid fuel from the previous cycle. If liquid fuel escapes at the exhaust some of this action is certain; moreover, much of the cylinder wear ascribed to the use of water has been due to this very action. If the cylinder walls are awash with light fuel, the cylinder oil is cut, reducing its viscosity and effectually destroying its value as a lubricant. No liquid fuel will reach the cylinder walls or exhaust with a proper injection system and a well-designed combustion chamber.

It is sometimes stated that the dissolved solids in the water will precipitate and cause abrasion. It is the writer's experience that with water fit for boiler use, carrying not more than six hundred parts per million of solids, such action is negligible. The most careful observation of carefully designed engines has failed to establish any marked limits. Sea water, water of pronounced brackish taste, turbid water, mine pumpage, etc., are of course out of the question.

This about covers the propaganda on the subject. It has often seemed to the writer that the really important facts in the case have been entirely obscured in talk. It has been stated that water injection brings about no thermal gain and that while it need not be an evil, under improper application it may be. The writer employs both systems commercially and owns but one true reason for the use of water injection; namely, it is possible to build large single-cylinder engines or engines of high power with fewer and larger cylinders without cooled pistons by its use.

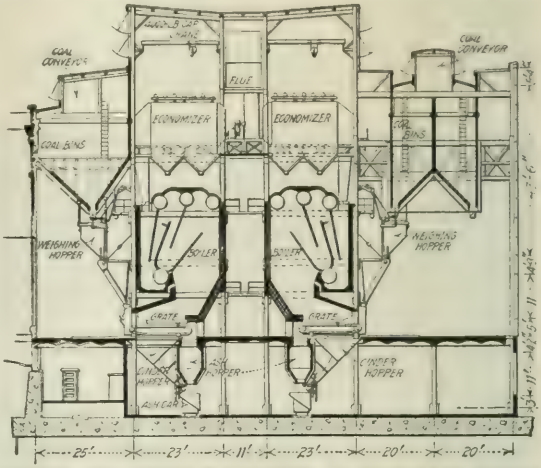
The untrained operator has not distinguished himself notably in the operation of multicylinder oil engines. The multicylinder gas or gasoline engine aspirates its charges from a single mixer or carburetor. In the semi-Diesel a separate fuel pump is required for each cylinder and each control mechanism must be adjusted so that its cylinder takes a due proportion of the load. Some means of adjustment is necessary in order to compensate for wear, but unfortunately such provisions serve equally well as means of misadjustment.

The semi-Diesel engine has a large overload capacity. It is rated at the point of best economy, which often is but two-thirds of its maximum capacity. Use of this excess in any one cylinder of a multicylinder engine may bring about destructive heating and abrasive carbon deposits, and such a condition will follow inadvertently faulty adjustment. Judgment is required to balance a multicylinder oil engine, and there is not much of this particular kind of judgment available as yet. Time and education may alter the situation.

In justice to the many builders of semi-Diesel engines employing water injection it may be added that water injection has several minor advantages that are worthy of consideration. Its use provides a cooler full-load air charge and adds about 25 per cent. to the engine rating. It also compensates in a large degree for overheating due to back pressure or unfavorable exhaust systems. These latter are not necessarily the result of ignorance, but sometimes arise out of local conditions. It also permits the use of high continuous overloads without destructive overheating. Such overloads should not be provided, but when encountered due to a low estimate or to growth, this capacity is no mean advantage even at the inevitable loss in economy.

Stokers Placed Under Mud Drum

In that section of the Lake Shore station of the Cleveland (Ohio) Electric Illuminating Co., known as the 1918 addition, a new furnace design has been worked out, says the *Electrical World.* Its essential features are shown in cross-section herewith. The chain-grate stokers, instead of being placed in the usual way under the front of the boiler, are installed at the rear under the mud drum. An igniting arch extends under the mud drum, which sits rather high, its center line being 15 ft. 8 in. above the floor line. The boiler baffling is of the type known as "four-pass baffling." The gases, in passing through a boiler so arranged, enter the first bank of tubes at the top instead of the bottom. This puts the uptake also at the rear of the boiler and permits the gases, after passing through the two banks of economizers, to be taken off in a single centrally located flue. The table gives further interesting data:

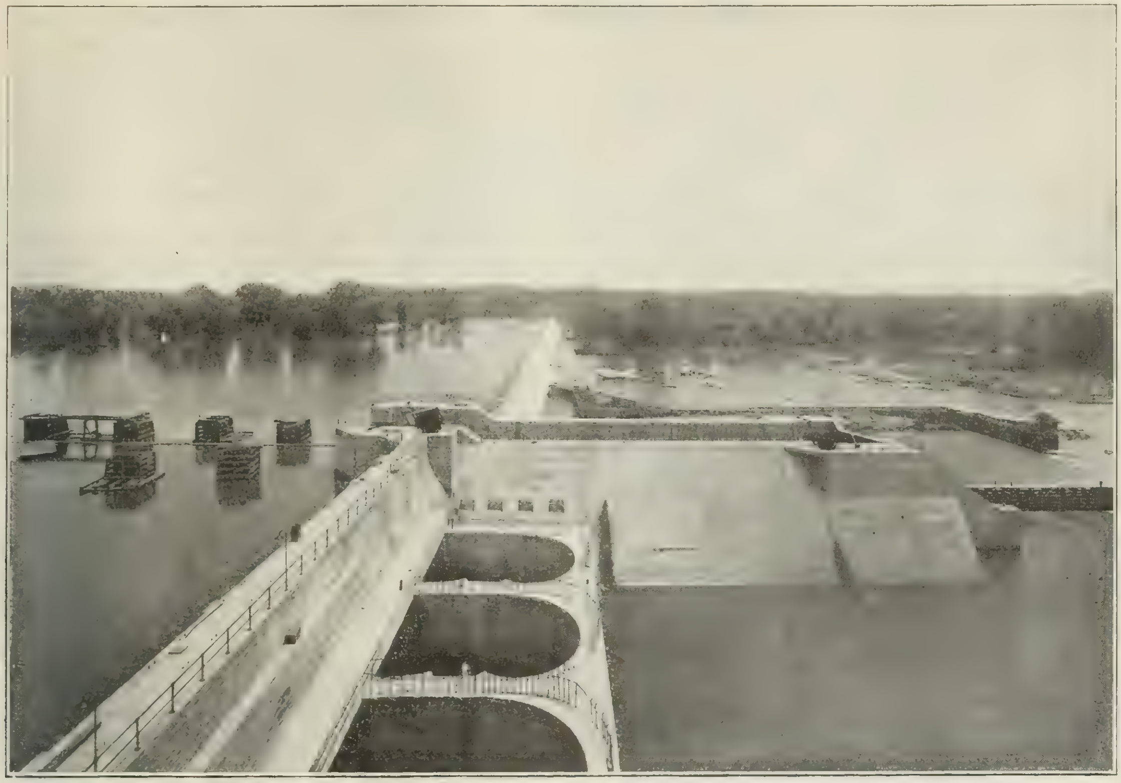


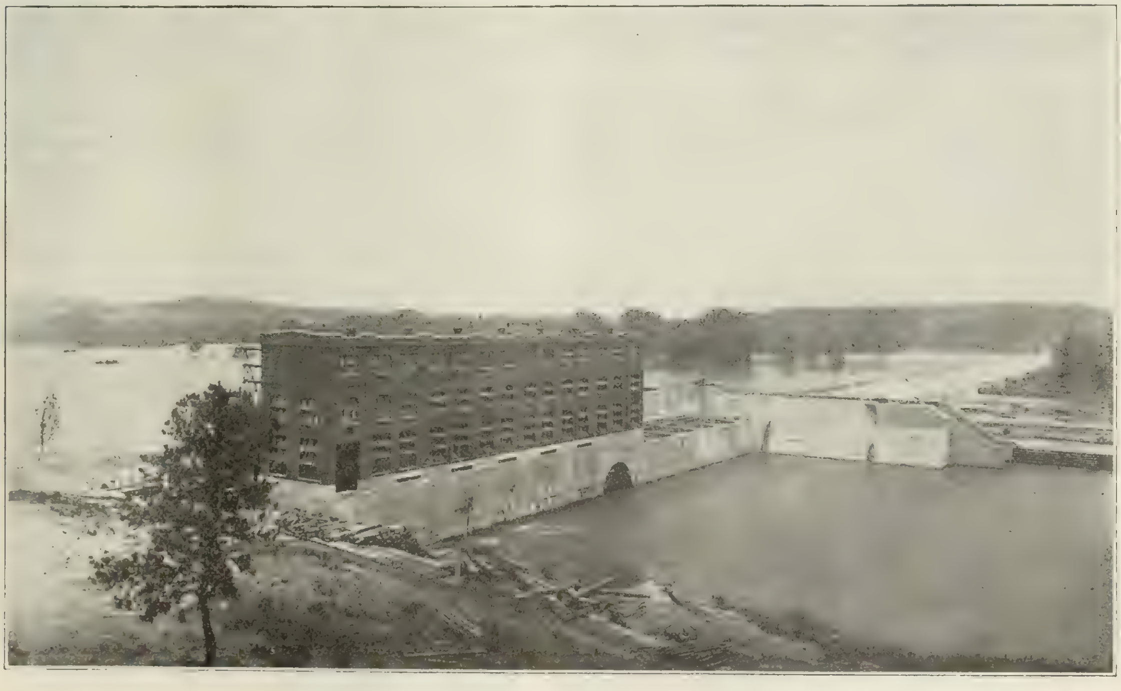
STOKER SET UNDER MUD DRUM OF FOUR-PASS BOILER

Type of boilers	Stirling, water-tube, class M-25
Type of stokers	Green, chain-grate, type L
Boiler rating in square feet of heating surface	6,864
Size of stokers	13 ft. long by 12 ft. wide
Grate area in square feet	156
Ratio of area to heating surface	1 to 44
Content of furnace in cubic feet	3,000
Cubic feet of furnace, volume per square feet of grate area	19

It will be observed that the furnace volume is higher than in many older installations. This is in line with the modern tendency of boiler-setting design.

Power House and Dam, Georgia-Carolina Power Company





The top view shows the concrete spillway dam 2000 ft. long and approximately 35 ft. high across the Savannah River near Augusta, Ga. To permit of navigation, a lock 30 ft. x 150 ft. in the clear had to be constructed near the power house at the Georgia end of the dam. The power house has an installed capacity of 15,500 hp., ultimate capacity 31,000 hp. The engineering and construction work was performed by the J. G. White Engineering Corporation, New York.

The Electrical Study Course—Factors Entering Into Brake Tests

Develops the theory of several types of brakes and points out the precautions that must be observed to secure correct values of the forces concerned from the readings of the scales.

IT WAS shown in the preceding lesson that an arrangement such as that illustrated in Fig. 1 could be used to make a brake test on a motor, but that it would require critical manipulation of the weight at W_2. A modified form of the test was referred to; such a one uses the arrangement illustrated in Fig. 2, which is one of the forms of brakes described in a previous lesson. With the pulley at rest the tension of the strap will be the same at both ends when the nut *c* is tightened. Consequently, when the beam scale *d* is in equilibrium, it will record the same pull as does the spring balance *e*. When the pulley is rotated in the direction of the arrow *A*, however, it tends to pull down on the strap at *a* and to push up at *e*. The result is that the counterpoise *f* will have to be set farther out on the beam *d* to keep it in equilibrium and will thus indicate the pull at *a* due to the combination of the pull at *e* and the pull due to the friction between the belt and the pulley. The pull at *e* corresponds to that of W_2 in Fig. 1, whereas the pull at *a* corresponds to that of W_1, and their difference, $W_1 - W_2$, is the force with which the motor pulley is trying to drag the strap around.

The load on the motor is controlled by means of the nut *c*, Fig. 2. Tightening it increases the tension on the strap and consequently increases the friction between it and the pulley, whereas loosening it has the opposite effect. When the nut is tightened, the scale *e* will show a greater reading and likewise the counterpoise *f* will have to be moved until it also indicates a greater reading, if *d* is to be kept in equilibrium. That is, tightening *c* causes an increase in the readings of both *e* and *f*, and hence it might appear that the load on the motor is not increased. However, it will be found that the reading of *d* increases more rapidly than that of *e*, causing their difference to be greater, and consequently causing an increase in the load on the motor.

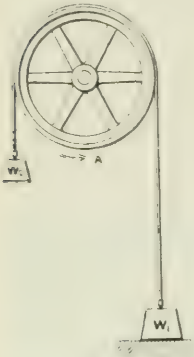


FIG. 1. TWO-WEIGHT SCHEME OF BRAKE

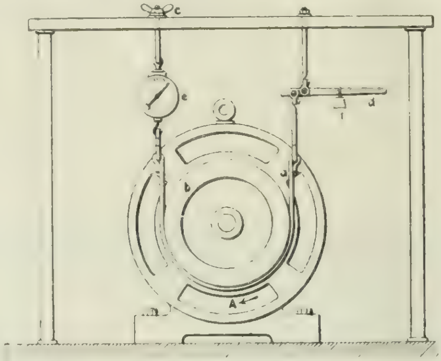


FIG. 2. BRAKE USING TWO SCALES FOR MEASURING OUTPUT OF MOTOR

It is evident from the foregoing that the method discussed provides a convenient means of obtaining the output of a motor and hence of determining its efficiency. The details of the manner in which such a test is performed will be presented, but before doing so it will be well to give consideration to that method of testing which employs the prony brake and investigate in what manner its theory of operation differs from that of the one just discussed.

For this purpose we can select any one of the forms already described; the same theory applies to all. Suppose, therefore, that we choose the one illustrated in Fig. 3. As in the preceding case, tightening the nut *c* increases the friction between the strap *a* and the pulley *b*, and by means of it the drag on the pulley can therefore be regulated.

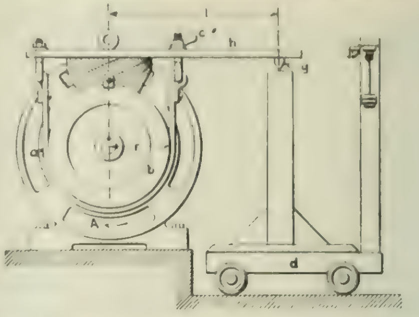


FIG. 3. PRONY BRAKE FOR TESTING MOTOR

The force dragging at the surface of the pulley cannot be determined directly in the case of the prony brake, since no scales are connected to the strap as there are in Fig. 2. But the force pushing down at *g* can be measured by means of a scale such as *d*, and this force, which we will call *f*, is due to the force with which the pulley is trying to drag the strap with it. If we let *F* represent the force at the face of the pulley, we have that, *F* is to *f* as the distance *l* is to the distance *r*; that is, as the length of the arm *h* is to the radius of the pulley. Expressing this relation in symbols, we have, $F : f = l : r$, from which we get that $F = \frac{f \times l}{r}$. Since *f* can be determined by means of the scale *d*, and *l* and *r* can be measured, it follows that *F*, the force at the face of the pulley, can be computed, after which the output of the motor can be calculated in exactly the same manner as in the case of the other test, by substituting the value of *F* in the formula $P = \pi \times D \times S \times F$, in which *D*, the diameter of the pulley, is equal to $2 \times r$. Writing $2 \times r$ for *D* would give us $P = \pi \times 2 \times r \times S \times \frac{f \times l}{r}$, in which the two *r*'s would cancel out, leaving $P = 2 \times \pi \times S \times f \times l$, from which it is evident that the diameter of the pulley does not have to be determined when the prony-brake method is used.

In applying any of the methods that have been discussed, certain precautions must be observed regarding the direction in which the forces are made to act on the scales. In the case of the spring balance the pull must always be in line with the scale, and in the case of the beam and platform scales it must be directly downward; that is, in a vertical direction. Thus, in Fig. 4 the belt at *a* might have the direction shown and yet the correct results would be obtained if the spring balance *l* were in line with it as it is represented. If, however, the balance were not free to swing, and in consequence occupied a position such as that illustrated in Fig. 5, the results obtained would be in error. Likewise, if the pull on the beam or the pressure on the platform scale were at an angle, as indicated in Figs. 6 and 7, respectively, instead of straight down, the results obtained would be incorrect.

The principle underlying the foregoing can probably be most readily demonstrated by considering the extreme cases; namely, when the pull or thrust is at right angles to the scale, as illustrated in Figs. 8 and 9. Thus, in Fig. 8, tightening the nut *c* would not put any tension on the strap, and whatever pull there might be on the strap at *a* due to the revolving pulley, would be exerted sidewise on the beam and would therefore have no tendency to pull the end *m* downward. Since it is necessary that a force act downward at *m* before it can be counterbalanced by the weight *f*, it is evident that no reading would be obtained on the beam no matter how large a force might be straining at the belt. In Fig. 9 the contact edge *g* is shown pushing against a block *n* that is supposed to be fastened to the platform of the scale to prevent the entire brake from whirling around, which it would otherwise be free to do. The force acting at *g* would have no tendency to push the platform of the scale downward and, therefore, there would be no weight indicated on the scale other than that of the block *n*.

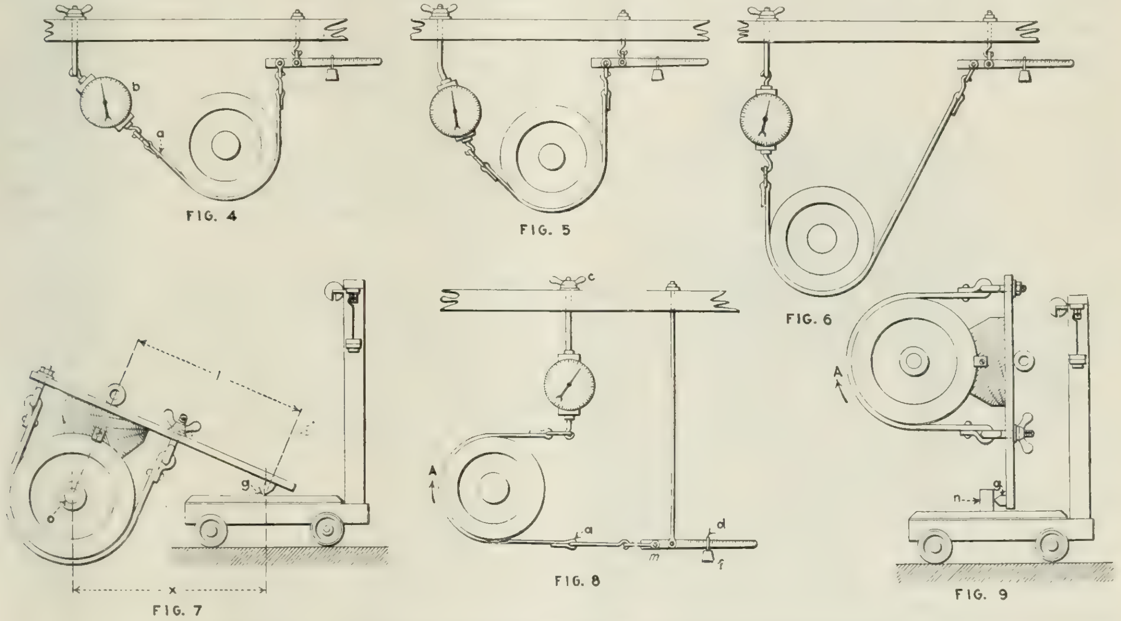


FIG. 4

FIG. 5

FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIGS. 4 TO 9. PRONY BRAKES OPERATING IN DIFFERENT POSITIONS

As a matter of fact a position of the prony brake such as that shown in Fig. 7 could be used if the horizontal distance between the center of the shaft and the point of contact *g* — indicated by *x* — can be determined. In that case the length *x* would be used in place of *l*. However, as the brake is tilted more and more, *x* becomes shorter and shorter until it reaches zero, when the brake occupies the position shown in Fig. 9. Long before reaching the zero position, the distance *x* would be so short that any slight error in measuring it would mean a large percentage of error in the results. Moreover, the shorter *x* becomes the greater would the pressure *f* at *g* become for the same pull *F* of the pulley, because $F : f = l : r$. This would require a large scale, whereas a small one will serve the purpose if advantage is taken of a greater length of arm, as in the position of Fig. 3. This position would be the one chosen since then the known value of *l* can be used instead of measuring *x*, as in Fig. 7, which is always a matter of more or less inconvenience. The foregoing brings out the important point that the distance between the center of the shaft *o* and the point of contact *g* must always be measured as the horizontal distance between perpendiculars through *o* and *g* (as *x*), and not as the direct distance between them.

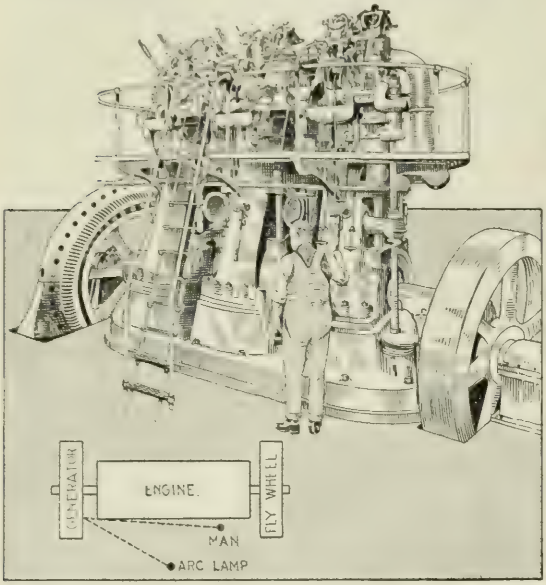
The problem of the preceding lesson stated that a 5-hp. motor which is being tested by the method indicated in Fig. 1 has a pulley diameter of 8 in. and runs at a speed of 1200 r.p.m. at full load. It was required to determine the value of the weight W_2 necessary to impose full load on the motor if the weight of W_1 is 100 lb. Since it is a 5-hp. motor, its full load would be 5 hp., and since there are 33,000 foot-pounds per minute in one horsepower its full load would be expressed by $5 \times 33{,}000 = 165{,}000$ ft.-lb. per min. This number of foot-pounds per minute would therefore be its output. From the preceding lesson we know that $P = \pi \times D \times S \times F$ foot-pounds per minute, where *P* is the output of the driven pulley, *D* its diameter in feet, *S* its speed in r.p.m., and *F* the force in pounds that opposes its rotation. In our problem *P* is 165,000 ft.-lb. per min., *D* is 8 in. (which in feet is equal to $8 \times \frac{1}{12}$, giving $\frac{2}{3}$ ft.), S is 1200 r.p.m., and F is equal to $(W_1 - W_2)$, of which W_1 is known to be 100 lb. and W_2 is to be found, giving us $F = (100 - W_2)$; π is of course equal to 3.1416. Substituting in the foregoing expression we have, $165{,}000 = 3.1416 \times \frac{2}{3} \times 1200 \times (100 - W_2)$, which reduces to $165{,}000 = 2513 \times (100 - W_2)$. We therefore have that $100 - W_2 = \frac{165{,}000}{2513} = 65.66$, from which $W_2 = 100 - 65.66 = 34.34$ pounds.

A motor is tested by means of a prony brake as in Fig. 3. When the force acting on the scale is 17 lb., the speed of the motor is 1500 r.p.m. If the length of the arm l is 20 in., what horsepower is the machine delivering?

Arc Lamp Used as a Synchronoscope

By W. H. Moore

A number of years ago I was employed in one of the old lighting plants where the load was growing faster than the plant and where the new apparatus was placed alongside of some antediluvian masterpieces and the whole collection made an outfit that was both unique and terrible.



RELATIVE LOCATIONS OF ARC LAMP, MAN AND ENGINE DURING SYNCHRONIZING

One evening when the load was coming on the switchboard operator was synchronizing an engine-driven alternator to go in on the bus and I happened to be looking at the flywheel of the engine, which was in the bright light of an inclosed arc lamp hanging close by. I noticed a shadow that seemed to be moving first with the rotation of the flywheel, then against the rotation and then finally stood still. When the shadow stopped, the operator closed the switch and the machine was in. This was before the synchronoscope was in general use in small plants, so we had to depend on lamps.

From the foregoing experience it was concluded that the spokes of the flywheel acted as a sort of synchronoscope. To prove it, the machine was taken off the bus and then put in again and with the same result. We found that when the shadow was going with the rotation the engine was running too slowly, when the machine was going against the rotation the engine was going too fast, and when the shadow stood still the engine was running at synchronous speed. We also found that synchronous speed did not always mean that the generator was in synchronism with the system. After we had made a few bad "shots," we decided that the latter was the truth. However, we found that the idea of using the shadow worked out very well, owing to the fact that the man at the engine could not see the lamps at the switchboard, and after it was found just how far we could go with the shadow, putting that particular machine in was much easier than before.

Some time later I had occasion to make good use of the shadow idea after taking a position in a lighting plant where there was a Diesel engine in an annex to the main engine room. The engineer could not see the switchboard, and it took three men to synchronize the generator—one man at the switchboard, one at the Diesel-engine governor and the third standing where he could see the synchronoscope and signal the engineer to run the engine faster or slower. At the time I arrived they were considering installing an additional synchronoscope in the Diesel room. Instead of this an arc lamp was hung near the engine and where the light would fall directly on the polepieces of the generator; a white stripe was painted on each polepiece, and the governor was manipulated according to the direction the shadow was moving.

The Diesel engine was direct-connected to a revolving-field alternator. The flywheel was on the right-hand end of the engine, as in the figure, as was also the governor. The angle of the two lines can be found only by experiment. The rays from the lamp should strike the moving fields at the top a little back of the center line for the best results. We took down and rehung the lamp a number of times before we found the proper position.

We have become so used to hearing that "Service is the greatest thing in the world," that there is grave danger we may become calloused to its real meaning and spirit. The American people delight in catch phrases, many of which are wonderfully expressive; nevertheless, we must beware of "glittering generalities." Service—service? What is service? Lawyers, scientists, clergymen, and laymen have endeavored to explain, but when all is said and done it is simply doing something for somebody which needs to be done. Into service rendered on a commercial basis must go the integrity of the men behind the transforming machinery; the application of correct scientific principles; the assembling and skillful preparation of machinery and complicated systems of delivery; reliability, and efficiency. Service *is* the greatest thing in the world when it embodies that spirit of its promoters which continually looks forward to improvement and progress.

In *Power* for Apr. 22 appeared an article dealing with various clinker grinders, their design and operation. The caption of Fig. 8 of that article was: "Commonwealth Edison Co., Chicago, Westinghouse Type Clinker Grinder." The wording is such as to infer that this grinder was installed in one of this company's stations. The view represents a study only.

EDITORIALS

Fires in Turbo-Alternators

DURING the first part of 1918 *Power* published a number of articles on fires in turbo-generators. Up to that time there had been little said on this subject, but the discussion brought out the fact that many fires had occurred in machines of this type. During 1917 at least one electric-manufacturing company carried on a series of tests to determine the best methods of extinguishing these fires, and as a result of these tests it was apparent that steam, if supplied in sufficient quantities, was one of the most effective means. The subcommittee on generators of the Committee on Electrical Apparatus, for the year 1918-19, of the National Electric Light Association, made a special study of the problem of extinguishing and preventing fires in turbo-alternators, and an abstract of its report appears on page 950 of this issue. The seriousness of this problem is clearly brought out in the report by the statement that thirty operating companies in this country have had a total of no less than eighty-one fires in turbo-generators within the last three or four years.

There is little doubt that the condition brought about by the war had very serious effects in causing fires in generators. The heavy loads carried by these machines during this period and the inability to take the units out of service for proper cleaning and inspection, brought about by the heavy demands for power, were the direct cause of many of the fires. Even though the cooling air may be washed, it is impossible to prevent some dirt and oil from being carried into the machine. Since approximately the generator's own weight of air passes through it each hour the machine is in operation, it is evident that even if each cubic foot of cooling air contains only a minute quantity of dirt and oil, in a month's run considerable of this material will find its way into the machine. If this mixture of dirt and oil is ignited by a fan accidentally rubbing on one of the end bells or by static discharge at some point within the machine, it will soon be fanned into an intense heat by the volume of air passing through the machine, which will destroy even the mica insulation on the coils if the fire is not immediately extinguished. As pointed out in the committee's report, the inspection and cleaning of turbo-generators at more frequent intervals would seem to be very desirable and to have a direct bearing on the liability of fires from sources external to the windings.

It has been general practice to connect the generator to the busbars without any automatic protection because of the fear of erroneous operation. This practice has no doubt caused many disastrous fires in generators. When a breakdown occurs between coils or between the winding and grounds, unless the machine is almost instantaneously disconnected from the line and the field opened, not only the coils and insulation but the stator core will be destroyed. Experience with balanced-relay protection in this respect seems to indicate that where this protection is provided to disconnect the generator from the line when trouble occurs in the machine, the extent of the damage from fires may be greatly reduced. As pointed out in the report, this practice seems sound and manufacturers are urged to standardize upon the bringing out of both ends of all phase windings to the generator's terminal board on all units of five thousand-kilowatt capacity and larger, and also on smaller sizes where no appreciable increase in the selling cost of the unit will result, so that balanced relays may be installed.

Although, as previously pointed out, in the early development work of specially provided fire-fighting equipment for turbo-alternators the trend was toward the use of steam to extinguish the fires, at the present time the weight of opinion and practice is in favor of the use of water, there being a feeling on the part of many that there is danger of steam having a detrimental effect, due to high temperature, on the insulation of the machine. Owing to the lack of sufficient information at the present time, with the use of either steam or water for extinguishing these fires, it would appear that only the result of future experience can decide which is more advantageous. However, the committee is to be congratulated; it has done a real constructive work for the industry in correlating reliable information upon a subject concerning which little material was available previous to the time that this report was submitted.

Do We Want a Standards Association?

During the war, committees from the four national professional engineering societies, Civil, Mechanical, Mining and Electrical, and the American Society for Testing Materials working in connection with representatives of the departments of War, Navy and Commerce, founded what has been known as the American Engineering Standards Committee.

This committee, originally and intentionally, and still, a joint committee of the professional societies, coöperating with the Government but with its personnel and activities controlled by the societies which created and support it, has, with a growing sense of its opportunities and possibilities, revised its constitution, changing its name from the American Engineering Standards Committee to the American Engineering Standards Association, and providing for the admission of representatives of other societies and interests to membership. A statement of its purpose, furnished to the press by the secretary, will be found elsewhere in this issue.

The unification, correlation and supervision of the making of standards might perhaps to advantage be done by a national body of high-minded disinterested experts. It is not apparent that the best way to get such a body would be to invite representation from all sorts of interests and organizations, commercial as well as scientific, at five hundred dollars per annum per representative. A body which produces a standard need not submit it for the indorsement of the Association unless it chooses to do so. The amount of prestige that an instrument like the Boiler Code of the American Society of Mechanical Engineers would gain by its acceptance, approval or indorsement by such a national Association would depend upon the character and work of that Association. The failure of the Association to approve a code or standard might, in the hands of a clever lobbyist or manipulator, be made quite effective as a deterrent to its acceptance by legislative bodies or the public; and it may not be difficult to block the acceptance of a code which, as some codes do, places restrictions upon and occasioned inconvenience to a particular interest or industry in an Association to participation in the decisions of which the representatives of this and sympathetic industries are admitted at so much per head.

The plan evolved by the committee for its own reorganization is being submitted to the councils and boards of management of the founder societies, and it will be interesting to see what light their discussion may throw upon the project.

Simple Method of Determining Power-Factor Correction

WHAT is the combined power factor of two or more loads having different power factors? is a question that is too frequently considered, by operating men, as something for mathematicians to puzzle over and not for those with a limited mathematical training. Quite the contrary; the problem can be solved on the drawing board with nothing more than ordinary drawing tools, the resultant power factor and load being measured directly from a simple diagram. In an article "A Simple Method of Determining Power Factor Correction," on page 923 of this issue, Ralph Kelly gives a method of determining the power factor of a system having a known power factor after another load has been added to it also of known power factor, by the simple addition of straight lines to represent the loads in their proper inductive or corrective relation, after which the resultant load and power factor may be measured with a scale directly from the diagram. The examples given, on the application of this method, cover a sufficiently broad scope to make it easily applicable to almost every practical problem of power-factor correction.

Power-factor correction has come to be one of the most discussed elements in the generation and application of electrical power. Many of the central-station companies are making surveys of their power systems with the object in view of taking steps to improve the power factor wherever possible. Large industrial plants are also beginning to give serious consideration to the subject, consequently the operating engineer may well prepare himself to answer such questions as, What will the power factor of a given load be by adding a synchronous motor to carry a given mechanical load and operate at a certain leading power factor? Such problems, as shown by Mr. Kelly, can be easily and quickly solved by the addition of straight lines to represent the loads in their proper relation.

Of course, a knowledge of trigonometry is required to make the exact calculations, but if care is exercised in laying out the problem on the drawing board, the values measured will be only a fraction of one per cent. out with the figures that would be obtained by calculation, which is close enough for all practical purposes.

Concrete for Boiler Settings

DURING recent years boiler settings have received more attention in the matter of design and materials than had previously been given to them since the days of Watt. For other than most rare cases concrete has not been used for this purpose. There is no question about the cheapness of this material; but little is known of its behavior when subject to loads and at temperatures produced in boiler furnaces. The average engineer is afraid of it under such conditions.

The engineers of the Robert Gair Company, of Brooklyn, have used concrete extensively for buildings. The familiar group of concrete buildings at the Brooklyn end of the old bridge belong to this company. For the boilers in the old boiler room reinforced concrete was used for the settings, and cinder concrete, containing no sand, was used as lining for the furnaces. The boilers are hand-fired and have been in service about eight years, no material change from concrete having been made. So these engineers have had unusual experience with concrete for boilers and boiler houses.

Lately, considerable additional boiler capacity was required, and a place for the new boilers was made in one of the concrete buildings erected several years ago. The boilers are large, of the horizontal-tubular type, stoker-fired, and they, too, will have concrete settings, supported by reinforced-concrete columns which will be subjected to the heat of the furnace. The particulars of the settings, with weights, loads, and concrete mixtures, are described elsewhere in this issue. Most men will regard these settings as daring, and many will consider them positively dangerous. But the Gair engineers are confident of their safety and endurance. If reinforced concrete can be made safe for boiler settings, it will appreciably lower construction costs, and likely would be widely used for the purpose. In view of the Gair settings discussion of the subject seems opportune.

In a paper before the recent spring meeting of the American Society of Mechanical Engineers the author gave performance data on three large power plants in Arizona. The reason for the poor showing made by one station during a short period was that the chief engineer was ill and absent. The personnel is well organized too, yet the plant suffered appreciably when the chief was not there to coördinate things. The incident furnishes a lesson for many chiefs and managers.

According to reports of the Federal Board for Vocational Education, several disabled soldiers have elected a course in boilermaking. A rather strenuous occupation for a wounded man, but it proves that they are not looking for sinecures.

Engineers long ago discovered that keys were the proper things to fasten loose cranks. Government officials might profitably take a cue from the engine room in these days of I. W. W. and Bolsheviki.

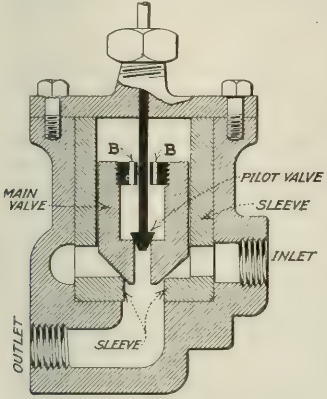
Considering the way it eats steam, the man who named the simplest form of steam engine was more accurate than he suspected when he called it the d—— slide-valve engine.

All the brine tanks in the country will be inadequate to contain the tears that will be spilled on the night of June thirtieth.

· Correspondence ·

Trap Valve Troublesome

Considerable trouble was experienced with a tilting trap which was arranged to handle the condensate from the separators on four 2700-kw. units. A study of the illustration will make the operation clear to anyone not familiar with the type of automatic valve used on this trap. Owing to the erosive action of the impurities conveyed through the trap by the condensed steam, it was impossible to keep the automatic valve in an operative condition for more than a few weeks at a time. The trap would tilt until it lifted the small pilot valve, but then it would stick, even with the most careful adjustment of the valve-stem packing and trunnion nuts. When the tilting chamber was filled with water, its weight was insufficient to overcome the pressure on the main valve and open it. Often the pilot-valve stem was bent or broken by the excessive strain. The trouble was frequently remedied by renewing the main valve and sleeve, and then the trap functioned properly, but in a few weeks conditions were just as bad as ever.



SECTION THROUGH VALVE

After the valve and sleeve had been renewed several times, I determined to find some less expensive method of obtaining service from this trap. I enlarged the main-valve passage about 50 per cent., and also the smaller passages *B B* a like amount, reasoning that the original cross-sectional area of these passages was not sufficient to pass all the leakage from between the main valve and the sleeve.

This same valve has been in service for several months operating at all times, often under the most adverse conditions, and so far has given no evidence of further deterioration. ROBERT W. RIORDAN.

Brooklyn, N. Y.

Armature-Coil Leads Were Broken

Motor troubles that cause sparking of the brushes, heating or slow starting, generally affect also the speed, and in such cases about the first test that a trouble man makes is a speed test. Unfortunately, many motors' name-plates give only the full-load speed of the armature, and unless some idea is had as to what the no-load speed should be, the speed test may suggest very little unless there is means of loading the motor and of measuring the load.

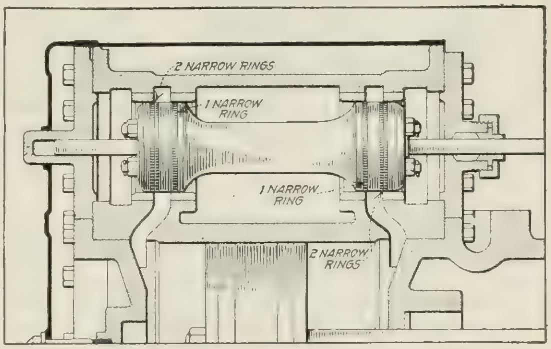
In a certain instance a 600-volt 30-hp. motor gave slight evidence of sparking when tested in the repair shop. The no-load speed was measured and appeared to be about what was to be expected, there being no way of putting a load on the machine. Nothing wrong could be found with the field coils or with the brushes, and the motor was sent to its destination, where its duty was to drive a stone crusher, and a shopman was sent with it to observe operation under load conditions. There was no ammeter for indicating the current taken by the motor, and the only device available for estimating the line voltage was a test circuit of five lamps connected in series, which showed by their brilliancy that the voltage was about correct.

As soon as the load was put on the machine, the sparking became worse and after about an hour's operation the armature began to smoke. The armature was removed and returned to the shop, where inspection disclosed that 21 coil leads were broken off at the commutator. Overloads combined with excessive vibration had produced this condition, and while the no-load speed apparently had not been materially affected, the heavier current of overloads caused the defect to manifest itself by the excessive sparking in a very positive manner. E. C. PARHAM.

Brooklyn, N. Y.

Used Two Piston-Valve Rings

In a plant in which I worked some time ago there was, among others, a piston-valve engine. One day about two hours before the peak load was due, the valve rod broke. We quickly removed the valve to replace the rod with a new one and found that two rings were broken on the valve, one narrow and the other a wide one. We had several narrow rings in stock but no wide ones.



USED DOUBLE VALVE RINGS

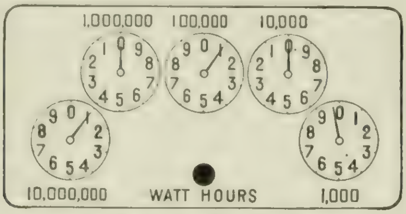
We needed the engine badly, and so the chief finally thought of the plan of taking two of the narrow rings and fitting them in the place of the wide one. This was done after some filing. The engine was then started and ran that way until we secured the proper rings for it. D. G. SIMMONS.

Hudson, N. Y.

What Does the Meter Read?

The following is given as an explanation to Charles A. Armstrong's question in May 20 issue of *Power*, "What Does the Meter Read?" with the dial pointers located as in the figure. Consider the extreme right-hand dial. It tells three things in this case: (1) Since one complete revolution equals 1000 watt-hours, each division is 100 watt-hours, therefore the last two figures in this number are 00. (2) The pointer has passed 9 but has not reached 0; therefore the last three figures are 900. (3) Since the pointer has not reached 0, the pointer on the next dial cannot have reached the figure it is nearest, although we do not know what it is yet.

Consider the next dial. The pointer is nearest 0; but we already know it has not reached 0, so the figure must be 9, making the last four figures 9900. Since this pointer has not reached 0, it follows that the next dial pointer has not reached the figure it is nearest. An inspection shows that the third dial pointer is near 1, but as we know it cannot have reached 1, the figure taken is 0, making the last five figures 09900.



WATT-HOUR METER DIAL

The third dial pointer, having passed 0, tells us that the fourth dial pointer has just passed some number. An inspection of the fourth dial informed us that it is 0, making the last six figures 009900. Since the fourth dial has passed 0, it follows that the fifth dial pointer must be just past a number. Referring to the fifth dial, this number is found to be 1, making the reading 1,009,900 watt-hours, or 1009.9 kilowatt-hours. About 40 watt-hours more on the dials would make the reading 1,010,000 watt-hours, or 1010 kilowatt-hours, and an experienced meter reader would undoubtedly read this amount, if this reading were encountered in the daily routine. In fact, in commercial work the lowest, or 1000, dial would be disregarded entirely.

Rainbow Lake, N. Y. **Victor H. Todd.**

I was interested to find when I had noted the reading in the meter-reading problem, in *Power*, May 20, that when I called the attention of two people who are reading meters every month, they read this setting incorrectly; namely, 1,010,900. It was amusing in the case of one of them because he thought it was my own meter reading and that I had caught him, since he saw his mistake as soon as I showed him the error.

A meter with such a recording arrangement, whether used for water, gas or electricity, should always be read backward. For example, in the reading under consideration, the 1000 dial shows 9 without question; the next dial (10,000) must also indicate 9 until the 1000 dial hand completes its revolution, by reaching zero. Following the same reasoning, the middle dial will not read 1 until the 10,000 dial hand has completed its rotation to the zero point. Then again, the 1,000,000 dial hand is 0 instead of 9, since the middle hand has passed the zero; and lastly, the first index reads 1 because the 1,000,000 dial hand has passed the zero. Therefore, the correct reading is 1,009,900 watt-hours, if the meter reads direct without a constant. **H. S. Dickerson,**

Rolla, Mo. Professor of Mechanical Engineering,
University of Missouri, School of
Mines and Metallurgy.

The correct answer to Mr. Armstrong's meter reading problem is 1,009,900 watt-hours.

The simplest proof that this is correct is to assume that the meter dial hands move forward until the dial hand to the extreme right is at 0. Then there is no question but that the correct reading would be 1,010,000 watt-hours. This being the case, the dial as pictured must be one unit less than this. **W. L. Durand.**

Brooklyn, N. Y.

With regard to the meter-reading problem presented by Mr. Amstrong in the May 20 issue, which refers to the article "How To Correctly Read a Watt-Hour Meter," by Victor H. Todd, in Mar. 25 issue, I believe the disagreement between Mr. Armstrong's associates is due to the statement by Mr. Todd on page 448, that in reading the five-dial watt-hour meter shown in Fig.11 of his article, the right-hand dial may be neglected.

If this right-hand dial is to be neglected and the meter read as though it had but four dials, it should not be permitted to influence the reading of the remaining four dials and the second right-hand dial should be read to the nearest figure. Therefore Fig. 11 of the original article should have been read as 1189 instead of 1188 kilowatt-hours as stated, and Mr. Armstrong's meter should read as 1010 kilowatt-hours. However, if the right-hand dial is to be considered in reading the meter it must be remembered that its indications are in fractions of a kilowatt and it may therefore be neglected if its reading is less than 5, but the second right-hand dial should be read to the highest number between which the pointer stands, if the reading of the first dial is 5 or more. This may be what Mr. Todd had in mind.

Of course, where there is a multiplier involved, the right-hand dial could not be neglected in any case. It may even be desirable to subdivide the divisions on this dial where the multiplier is large. For instance, Mr. Armstrong's meter might be read 100,997 with a multiplier of 100 and 1,009,970 with a multiplier of 1000, and so on. **George E. Lyons.**

Woodhaven, N. Y.

On page 792 of the May 20 issue there is shown a meter dial to be read. The average meter reader, I think, would read this meter 1010 kilowatt-hours, while it reads only about 1009.97 when considering the hands exactly as they are.

By disregarding the right-hand dial for a moment and then reading this meter it will be more easily seen what the true reading is. **Albion C. Barker.**

Mechanic Falls, Me.

I give the reading of the watt-hour meter dials in Charles A. Armstrong's problem in *Power*, May 20, as 1,0099+. Since the extreme right-hand dial has not completed its revolution until this hand reaches 0, it is obvious that the second dial cannot have reached a figure, regardless of the position of the hand with regard to the figure. Following out this line of reasoning, the third dial cannot have reached the figure 1 until the second dial has completed its revolution. The fourth dial has completed its revolution, since the third dial has completed a revolution, so the fifth dial has reached a figure regardless of the position of the hand, which in this case happens to be 1 and is correct.

It must be remembered that it is practically impossible to construct and mesh a number of gears such as are used in watt-hour meters without a small amount of back-lash, which accounts for the hands being slightly misplaced. It is a good idea for a meter reader to have the last two preceding readings of the meter to compare so as to avoid mistakes, although I can see no reason for errors if care is exercised.

Five of my men reading the dial given by Mr. Armstrong, gave the following readings: 09,109; 10,109; 10,009; and 10,100 respectively as off-hand readings, showing the need of stopping to think over the positions of the hands before reading.

The first, or lowest, dial on a meter is always driven by the measuring mechanism and must therefore be in perfect mesh and as a result should always be correct no matter what its position; the other hands are driven by gears from the first hand and have more or less back-lash and may be a little farther ahead or behind the figure than the correct reading calls for.

Ringwood Manor, N. J. **Allan A. Blanchard.**

[To say the least, the interest shown by *Power* readers in the problem, "What Does the Meter Read?" is very gratifying. To date 31 answers have been submitted. It is impossible, much as it may be regretted, to give the space necessary to publish all the discussion submitted. The foregoing were selected to represent in a general way the opinion expressed in the large number of letters received. The following are the names of other contributors: Henry Mulford, Patchogue, N. Y.; R. A. Cultra, Cambridge, Mass.; E. A. Fischer, Newark, N. J.; George L. Rougier, Mittineague, Mass.; Theodore Haight, New York City; Charles D. White, Port Clinton, Ohio; W. F. Hubbell, Traverse City, Mich.; C. H. Adams, Coatesville, Penn.; John E. Ketchen, Simsbury, Conn.; D. Fliegelman, Bridgeport, Conn.; C. L. Follmer, Saranac Lake, N. Y.; E. H. Quinter, Minersville, Penn.; Thomas M. Gray, Bayonne, N. J.; Patrick Molloy, New York City; Walter Carr, Elwood, Ind.; M. T. Wadkins, Springfield, Ill.; D. H. Reynolds, Minneapolis, Minn.; R. Manly Orr, Vancouver, B. C., Canada; Harry A. Klein, Jr., Monroe, N. Y.; E. A. Brown, Rochester, N. Y.; Joseph Dalke, Chicago, Ill.; Joe Smith, Castlegate, Utah; Charles E. Schrock, Chicago, Ill.; Lambert E. Reznor, Greenville, Penn.; Frank L. Schlick, Montour Falls, N. Y. The opinion has been expressed in some of the discussion, not published, that one or more of the dial hands were misplaced. However, it would be quite difficult to place the hands more accurately than they are, if for no other reason than the slight looseness present in all meter-gear trains.—Editor.]

Evidence of Leaky Condenser Tubes

In answer to the question, "How does leakage of tubes in a surface condenser become known?" in the issue of Mar. 25, page 467, it is stated that there will be loss of vacuum from air leakage into the condenser and an excessive delivery of water to the hotwell.

There can, however, be quite a fair leakage without the vacuum being affected, and at the same time the excess or extra water may easily escape notice. There is always a certain amount of makeup water required, and in the average plant a lot of water is wasted through the overflowing of the feed-water heater.

If the circulating water is salt, a small leak can readily be detected by drawing about a pint of water from the hotwell and adding a drop of silver nitrate solution, about 1 in 20. If there is a small leak, the water will become milky when the solution is added. A little experience will teach one how serious the leakage is. The average air pump can handle a little air leakage from tubes, and the condensate pump can take care of a little extra water without the vacuum suffering.

I was in charge of a plant in which one of the units was second-hand. The condenser was not in a very satisfactory condition. On one occasion leaky tubes yielded so much extra water that the condensate pump could not get rid of all of it. Another machine, operating jet condensing, was cut in on the bus and given 1000 kw. from the other unit.

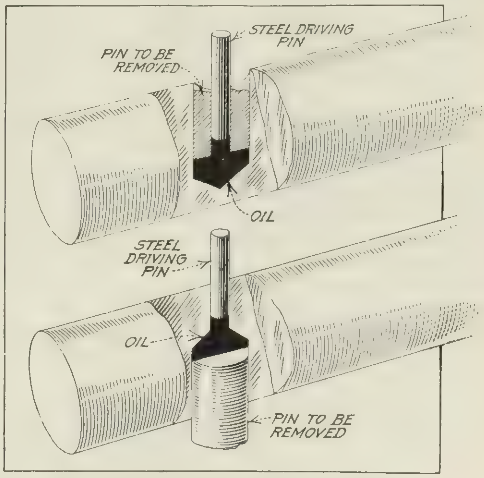
Even at that no makeup water was required, and a vacuum of fully 29 in. was easily obtained on the leaky condenser, using the mercury column. The vacuum was reduced, however, to see what effect that would have on the excess water. Luckily, the circulating water was fresh. **J. B. Tait.**

New Westminster, B. C., Canada.

Removing A Tight Pin

Frequently, a pin becomes rusted or broken off in a shaft or other piece of metal in which it has been driven. One way to remove it without damaging the hole in which it is driven is shown in the illustration. A small hole is drilled through the pin or through the piece of material directly opposite the end of the pin. Oil is then put into the hole so as to fill it to about one-half the length of the drilled hole and a tight-fitting pin is inserted in the hole. When this pin is struck a severe blow, a pressure is exerted upon the pin to be removed sufficient to force it out. This method will be found effective. **W. W. Parker.**

Guantanamo, Cuba.



TWO WAYS OF REMOVING A TIGHT PIN

Wastes Due to Leaky Boiler Settings

The article by Harvey C. Hays on page 121 of the Jan. 28 issue has been read with considerable interest. Putting on asbestos paste two inches thick and following it up with canvas and paint is a good deal of a job and should be done only by experts in handling such material, and that would mean considerable expense. If the work is not done in an expert manner I doubt if the canvas would be sufficiently incorporated with the cement and the cement sufficiently incorporated with the brickwork to remain in place any great length of time. Covering a large flat surface in this way is one thing, and covering the same area interspersed with access doors or openings of any kind is quite another thing, in practical application and bondage.

My purpose, however, is not to criticize Mr. Hays, for he may have had experience in the class of covering that he suggests. What I have to say is more of a supplement to what he has brought out in regard to chambered boiler settings versus solid-wall boiler settings, and I trust that the discussion of the subject may cause some of the advocates of chambered walls to sit up and consider.

I was present, with others at a steam plant consisting of several horizontal fire-tube boilers, in company with a constructing engineer of note who had built this plant a few years previously. The chief engineer of the plant remarked that of the several boilers, the settings around half of them were chambered and it was assumed that the work had been done in a proper manner, yet there was a marked difference in the steaming capacity of the boilers. The other half of the installation, of precisely the same make and capacity, were set in solid-wall construction. Up to this time no information had been given as to which boilers had proved to be the better steamers or which had settings with chambered walls.

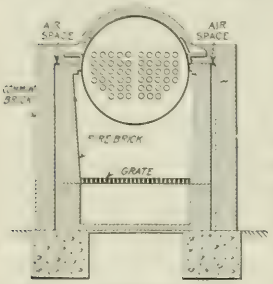


FIG. 1. SETTING WITH AIR SPACES

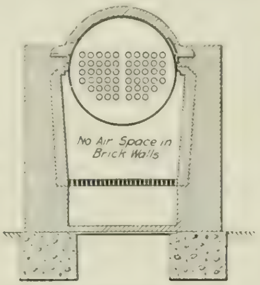


FIG. 2. SETTING WITHOUT AIR SPACES

In the course of the conversation the chief asked one of his visitors if there was anything, in his opinion, to indicate which settings were of solid-wall construction and which were the chambered walls. The man replied that in his opinion the cracked settings were of the solid construction and gave the reasons for his conclusion, but added that that was not saying that those boilers were not just as good steamers as the boilers without cracked settings, because if, as he had been told, all the boilers had been in service the same number of years and yet showed such marked difference in the condition of the outer walls, he was of the opinion that the air-chambered walls had simply fooled the engineer into assuming that his setting was *ne plus ultra*, and naturally he thought these boilers should steam the best when in reality they did not; and he said it was puzzling him.

When it was further explained that the inner walls of the chambered settings were doubtless much more seriously cracked than was apparent on the solid-wall settings and were leaking more air, it seemed apparent why these boilers were the poorest steamers. I do not assume, however, that this opinion in the matter of solid bricking up boilers will universally prevail; because there are men who have such settled conviction that an air-chambered setting is right that they will adhere to it on the same basis that a sick man takes a dose of medicine—doesn't like it, but thinks it must be efficacious, yet does not know why.

There is one other matter which I wish to add as a supplement to the letter of Mr. Hays on the subject of air-tight cleaning-out doors. It is only since the Government has made such an effort to conserve coal that particular attention has been given to air leaks of all kinds through boiler settings and especially to badly fitting access doors. To have a leaky door on a boiler setting seems inexcusable, and yet the majority of doors are of this character. If doors are constructed with metal-to-metal faces, whether such faces have been machined or not, it is safe to say that ninety-nine out of every hundred will leak air to some degree, and I also think it is a fair statement that in the majority of these ninety-nine cases the leakage is a serious one.

This leakage occurs not only around the opening of the door, but around the outside of the frame, especially in door frames that are not furnished with anchor bolts, but in which a projecting hooked flange is provided on the frame, which, when the frame is masoned in place, is supposed to remain tight and secure against leaks. I have seen door frames, however, so loose that a slight effort would pull them out. I have been building, for the past few years, access and inspection doors that are tight and remain so. However, during the late war it had almost resulted in a labor of love to furnish them, because of the exceedingly high prices of material and labor. **O. C. Woolson.**

New York City.

Dividing Box with Condensing Head

Referring to the criticism on page 328 of the Mar. 4 issue of *Power*, on the dividing-box apparatus, which was designed by the writer and a description of which was published on page 132 of the Jan. 28 issue, I will say that the V-shaped notches in the supply pipe to the feed-water heaters are used in the regular dividing boxes at present installed in several of the largest power plants in this country.

This condensing head is to be used with the open type of feed-water heaters, and is designed to be used for efficient installations where the water temperature never falls below 210 deg. F. and is generally carried at 212 deg., and sometimes higher, by means of a back-pressure valve in the heater exhaust pipe.

The only air that enters the condensing head from the heater-vent inlet is that which is already in the heater; that is, instead of the air going out through the ordinary heater-vent pipe, it goes out through the dividing box.

The water-storage surfaces of open-type feed-water heaters are ample to allow entrained air to escape

New York City. **Howard C. Thayer.**

Inquiries of General Interest

Improving Soiled Tracings for Blueprinting—What is a good method of improving the transparency and smoothness of drawings and tracings made on tracing cloth that have become soiled and crumpled from use, so they may be made more suitable for blueprinting? H. F. T.

The transparency can be improved by lightly rubbing off the grease and dirt with a tuft of absorbent cotton moistened with benzine, gasoline or one of the commercial cleansing preparations of carbon-tetrachloride. The smoothness can be improved by ironing the drawing covered with a smooth piece of tracing cloth, observing, however, that the sadiron used is not so hot as to render the glazing material opaque.

Pitting and Corrosion of Idle Boiler—During intervals of several weeks at a time it is necessary to keep several of our boilers standing filled with water to be ready for promptly steaming when required. We are troubled with corrosion and pitting of the tubes. Would our irregular use of the boilers be the cause? W. M. L.

When boilers are left standing filled with water, it is best to fill them to overflowing. Otherwise there will be more active corrosion in the steam spaces, especially at the water line. Pitting of the tubes should be less active than when the boilers are in use. If it takes place as fast or more rapidly than when the boilers are in use, the trouble may be due to electrolysis caused by improper grounding of local electrical circuits.

Determining and Adjusting Piston Clearance—How is it determined whether an engine connecting-rod is of correct length to give equal piston clearance at each end of the cylinder, and how is the length determined? R. W.

Make marks on the guide to correspond with a mark on the crosshead when the engine is placed first on one center and then on the other. Detach the connecting-rod from the crosshead and make marks on the guide to correspond with the mark on the crosshead when the crosshead, piston rod and piston have been moved so the piston is in contact first with one head of the cylinder and then with the other. The distance apart of these outside marks on the guide from the marks made with the engine on the centers will be the amount of piston clearance at the corresponding ends of the stroke. Find the difference of these distances with a pair of dividers by laying off the smaller on the larger and add half of the difference to the smaller measured toward the middle of the stroke and laid off by a mark made on the guide. For equal piston clearance the connecting-rod should be adjusted to such a length that the mark on the crosshead will come opposite to the mark last made on the guide when the crank is on the corresponding center.

Drop of Pressure in Steam-Pipe Line—For operating an ice machine our power plant supplies steam at 120 lb. pressure to a 2-in. pipe line 600 ft. long in which there is a drop of pressure of 20 to 25 lb. per sq.in. Could not the loss be prevented by having the steam line discharge into a receiver, or should there be a larger size of pipe line? C. L. S.

Some of the pressure drop is due to loss of heat from radiation, but if the pipe line is fairly well protected with an insulating covering, the drop of pressure in excess of 5 to 10 lb. is mainly due to the rate at which the steam is drawn from the discharge end of the line. By discharging into a receiver it is probable that the steam, as used by the ice machine, could be supplied at steadier pressure and thereby be better for operation of the ice machine, but the same quantity of steam used per hour would be discharged at about the same average pressure. Neglecting the somewhat greater loss by radiation from use of a larger pipe, the same quantity of steam could be delivered per hour with a 2½-in. pipe line and drop in pressure of about 9 lb. per sq.in. and with a 3-in. pipe it would be about 5 lb. per sq.in. Drop of pressure in a steam-pipe line is indicative of a restraint of the flow similar to throttling. The reduction of pressure does not constitute a loss in the sense of a waste except when so construed with reference to the manner in which the steam is used.

Allowance for Room Temperature Negligible—In using a thermometer for obtaining the temperature of feed water, what allowance should be made for temperature of the surrounding atmosphere? L. N.

Standard mercury thermometers for measuring the temperatures of liquids have scales graduated on their glass stems and usually are marked to show the depth to which their bulbs should be immersed for obtaining readings when the stems are exposed to ordinary room temperatures. When such a thermometer is used in a different room temperature from that for which it was calibrated, but with correct immersion of the bulb, there will be an error due to variation of the relative expansion of the mercury column and of the graduated stem, but the error is so very small compared with the personal errors of observation that, for all practical purposes, it can be neglected.

Adiabatic and Isothermal Compression of Air—If 10 cu.ft. of air at atmospheric pressure and at the temperature of 60 deg. F., is compressed to 1 cu.ft. without any loss of heat, what will be the pressure and the temperature; and if the temperature is maintained constant, what will be the pressure? D. D.

When there is no transmission of heat from or into the air during expansion or compression the operation is said to be *adiabatic*. The formulas giving the relations of pressures, volumes and temperatures for adiabatic compression of air or other sensibly perfect gases are,

$$\text{(a)}\quad \frac{p_2}{p_1} = \left(\frac{v_1}{v_2}\right)^{1.405} \qquad \text{and} \qquad \text{(b)}\quad \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{0.405}$$

in which p_1 = initial absolute pressure, p_2 = final pressure. v_1 = initial volume, v_2 = final volume, T_1 = initial absolute temperature and T_3 = final absolute temperature.

Having p_1 = one atmosphere or 14.7 lb. absolute, v_1 = 10 cu.ft., and v_2 = 1 cu.ft., by substitution equation (a) becomes

$$\frac{p_2}{14.7} = \left(\frac{10}{1}\right)^{1.405} \text{ or } \log p_2 = \log 14.7 + (1.405 \times \log 10)$$
$$= 2.572317,$$

from which p_2 = 373.5 lb. absolute, or 358.8 lb. per sq.in. gage.

Having $T_1 = 60 + 460 = 520$ deg. absolute, and the given value of v_1 and v_2, by substitution equation (b) becomes

$$\frac{T_2}{520} = \left(\frac{10}{1}\right)^{0.41}, \text{ or } \log T_2 = \log 520 + (0.41 \times \log 10)$$
$$= 3.126003,$$

from which T_2 = 1336.6 deg. absolute, or 876.6 deg. F.

If the air during compression is kept at a constant temperature, the operation is said to be *isothermal* and the formula giving the relations of volumes and pressures is (c) $p_2 v_2 = p_1 v_1$, and substituting the given values equation (c) becomes

$$p_2 \times 1 = 14.7 \times 10, \text{ or } p_2 = 147 \textit{ lb. absolute} = 132.3$$
lb. per sq.in. gage.

[Correspondents should sign their communications giving full names and post office addresses.—Editor.]

Tentative Code for the Regulation of Refrigeration Plants

FOLLOWING is the Code recently adopted by the American Society of Refrigerating Engineers:

SECTION 1

This act shall apply to every refrigerating machine employing ammonia, carbon dioxide, ethyl chloride, or sulphur dioxide as a refrigerant. The following definitions shall apply in the interpretation of this act:

(a) A "refrigerating machine" is a mechanical device, including its source of energy in so far as its affects its safety of operation, for abstracting heat for a useful purpose from a body at one temperature and transferring it to another at a higher temperature.

(b) The term "large" is intended to designate machines of 3 tons capacity or over, or containing 100 lb. of refrigerant or over, and the term "small" is intended to designate machines of under 3 tons capacity, or containing less than 100 lb. of refrigerant. (Note: Such machines, together with the various and alternate safety means prescribed in these regulations, are illustrated in Figs. 1 and 2.)

(c) A "pressure imposing element" is that part of a refrigerating machine, such as a "compressor," or "absorber" and "generator," into which the refrigerant flows under low, and is discharged under high, pressure.

(d) A "safety valve" is a mechanical device for automatically relieving pressure in excess of that for which it is set.

(e) An "automatic bypass valve" is a mechanical device for automatically relieving excessive pressure on the discharge side of the pressure-imposing element to the suction side of that element.

(f) A "liquid receiver" is a container, connected between the condenser and the evaporator, for the storage of liquid refrigerant pending its employment for the production of refrigeration in the evaporator.

(g) A "cylinder" is a container for the shipment of a refrigerant.

(h) The "capacity" of a refrigerating machine is its builder's standard rating in tons of refrigeration per 24 hours.

(i) The terms of "main suction" and "main discharge" valves are intended to designate the stop-valves located in the suction and discharge lines, respectively, adjacent to the pressure-imposing element.

SECTION 2

Every "large" refrigerating machine shall be equipped with one or more automatic safety valves of proper size, connected to the discharge line between the pressure-imposing element or elements and the main discharge stop-valve, set to relieve excessive pressure and sealed. The sizes and pressures at which such valves are to be set shall be as follows:

For machines of from	3 to 25 tons capacity	use 1, ½-in. valve
	26 to 60 tons capacity	use 1, ¾-in. valve
	61 to 100 tons capacity	use 1, 1 -in. valve
	101 to 175 tons capacity	use 1, 1¼-in. valve
	176 to 250 tons capacity	use 1, 1½-in. valve
	251 to 450 tons capacity	use 1, 2 -in. valve
	451 to 900 tons capacity	use 2, 2 -in. valve

For machines employing	ammonia,	set valves to open at not over	300 lb.
	carbon dioxide,	set valves to open at not over	1800 lb.
	ethyl chloride,	set valves to open at not over	60 lb.
	sulphur dioxide,	set valves to open at not over	150 lb.

SECTION 3

Every refrigerating machine shall be equipped with one or more automatic bypass valves of proper size, connected between the pressure-imposing element or elements and the main discharge stop-valve, set to relieve excessive pressures to the suction side of the machine. It is recommended that such bypass valves be of the same size as the safety valves prescribed in Section 2.

For machines employing	ammonia,	set valves to open at	250 lb.
	carbon dioxide,	set valves to open at	1500 lb.
	ethyl chloride,	set valves to open at	50 lb.
	sulphur dioxide,	set valves to open at	120 lb.

SECTION 4

(a) Every liquid receiver shall have been subjected to a combined hydrostatic and hammer, or other approved form of vibratory, test prior to its being put into service. The hydrostatic pressure, according to the refrigerant employed, shall be as follows:

For machines employing	ammonia,	test pressure shall be	500 lb.
	carbon dioxide,	test pressure shall be	3000 lb.
	ethyl chloride,	test pressure shall be	150 lb.
	sulphur dioxide,	test pressure shall be	250 lb.

(b) Every liquid receiver of machines containing 25 lb. of refrigerant or over and having a stop-valve or check-valve, or both, between the condenser and such receiver, shall be equipped with a ½-in. automatic safety valve set to discharge to the atmosphere. There shall be no stop-valve or check-valve between such safety and the receiver.

For machines employing	ammonia,	set valves to open at not over	350 lb. pressure
	carbon dioxide,	set valves to open at not over	2000 lb. pressure
	ethyl chloride,	set valves to open at not over	100 lb. pressure
	sulphur dioxide,	set valves to open at not over	200 lb. pressure

SECTION 5

Every refrigerating machine containing 25 lb. of refrigerant or over, shall be equipped with emergency means for discharging the refrigerant in case of fire.

(a) in the case of "small" machines containing 25 lb. of refrigerant or over, such emergency means may comprise two ½-in. automatic safety valves, one connected by an emergency line to the discharge line from the pressure-imposing element at a point between the main discharge stop-valve and the condenser, and the other, by a similar emergency line, to the suction line between the evaporator and the main suction stop-valve. Such valve shall be set at the same pressure as the safety valves prescribed for "large" machines in Section 2. Check-valves may be installed to prevent water from entering the machine in case the refrigerant ammonia is to be discharged into water, but there shall be no other valve in the emergency discharge lines.

(b) In the case of "large" machines, such emergency means shall comprise hand-operated valves similarly connected, and located on the public thoroughfare side of the building wall, or in a vestibule having glass panel doors which will provide easy access from the street. The valves shall be located at a height of not more than five feet above the street or vestibule floor level and shall be protected by a suitable locked box to be opened by the members of the Fire Department only, by means of a "Fire Department inner box key," provided however, (1) that the emergency lines to such hand valves may be equipped with check valves, pressure gages and auxiliary stop-valves, to be used for repair purposes only, and (2) that such locked box may, at the discretion of the Fire Department, be equipped with an auxiliary locked door to be opened only by such person or persons as may be duly authorized by the Fire Department to make repairs. Such auxiliary stop-valves shall be located on the inside of the building as near as possible to the emergency device and shall be sealed open. The closing of such valves except for, and during, repairs shall constitute a violation of these regulations.

Except as above provided the Fire Department shall have sole access to, and use of, the emergency means and protecting box, which shall be plainly indicated by a suitable sign, reading "For Fire-Department Use Only." The high-pressure emergency valve shall be labeled "High-Pressure Ammonia," and the low-pressure valve, "Low-Pressure Ammonia." Where another refrigerant than ammonia is used, the name of that refrigerant shall be used in place of "ammonia." In case the refrigerant, ammonia, is to be discharged into the sewer, as provided in Section 7, paragraph (c), there shall also be within the box the sign "Do Not Open Valves Until Water Is Flowing Into The Mixer."

The Fire Department shall make necessary inspections and repairs of valves, emergency means and mixer.

SECTION 6

In the case of "small" machines in which there are no check- or stop-valves set, or capable of being set, to prevent the flow of refrigerant to the high-pressure side of the machine, the discharge line safety valve prescribed in Section 5, paragraph (a), will satisfy the requirements of Sections 4 and 5.

SECTION 7

The refrigerant passed by the automatic safety valves and the automatic or hand-operated emergency valves prescribed in Sections 2 and 5 shall be discharged to the atmosphere or into water through one or more of the following means:

(a) When discharged into the atmosphere the refrigerants, ammonia, carbon dioxide, ethyl chloride or sulphur dioxide, shall be conducted by continuous piping to an outlet turned upward and equipped with a suitable diffuser designed to mix the gas with air without materially restricting its flow. The piping from safety valve to point of final discharge shall be such as not to impose a pressure of more than 10 lb. on the discharge side of the valve. Such piping shall in no case have any connection with any pipe constituting a part of either a steam or plumbing system, or any means whereby the gases discharged might become ignited. No piping, stack or other conduit subject to serious corrosion or possible obstruction shall be employed. Outlets from diffusers shall in no case be less than six feet from any wall in which there is an opening, or less than ten feet above the roof. In the case of carbon dioxide the diffuser may be omitted.

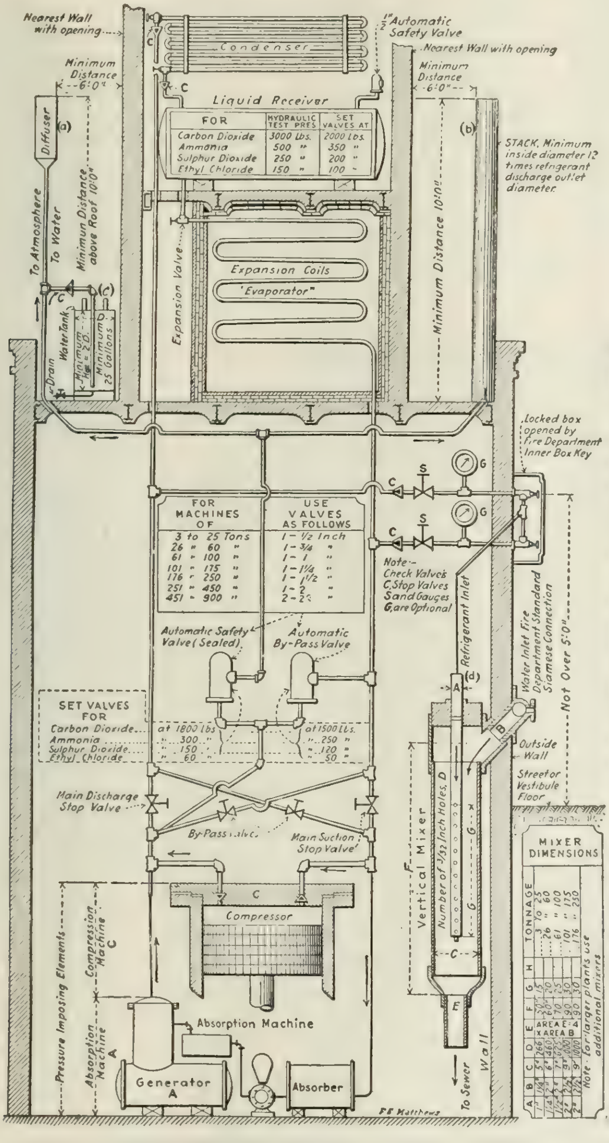

Nearest Wall with opening
½" Automatic Safety Valve
Condenser
Nearest Wall with opening
Minimum Distance 6'0"
Minimum Distance 6'0"
C
C
Liquid Receiver
FOR | HYDRAULIC TEST PRES | SET VALVES AT
Carbon Dioxide | 3000 Lbs. | 2000 Lbs.
Ammonia | 500 " | 350 "
Sulphur Dioxide | 250 " | 200 "
Ethyl Chloride | 150 " | 100 "
Diffuser
(a)
(b)
STACK, Minimum inside diameter 12 times refrigerant discharge outlet diameter
To Atmosphere
To Water
Minimun Distance above Roof 10'0"
Minimum Distance 10'0"
Expansion Valve
Expansion Coils
"Evaporator"
C
(c)
Water Tank
Minimum Hgt. = 2 D.
Minimum D. 25 Gallons
Drain
Locked box opened by Fire Department Inner Box Key
C
S
G
C
S
G
FOR MACHINES OF | USE VALVES AS FOLLOWS
3 to 25 Tons | 1 - ½ Inch
26 " 60 " | 1 - ¾ "
61 " 100 " | 1 - 1 "
101 " 175 " | 1 - 1¼ "
176 " 250 " | 1 - 1½ "
251 " 450 " | 1 - 2 "
451 " 900 " | 2 - 2½ "
Note:- Check Valves C, Stop Valves S and Gauges G, are Optional
Refrigerant Inlet
Water Inlet Fire Department Standard Siamese Connection
Not Over 5'0"
Automatic Safety Valve (Sealed)
Automatic By-Pass Valve
SET VALVES FOR
Carbon Dioxide ... at 1800 Lbs. ... at 1500 Lbs.
Ammonia ... " 300 " ... " 250 "
Sulphur Dioxide ... " 150 " ... " 120 "
Ethyl Chloride ... " 60 " ... " 50 "
(d)
A
B
Outside Wall
Street or Vestibule Floor
Main Discharge Stop Valve
By-Pass Valve
Main Suction Stop Valve
Vertical Mixer
F
Number of 3/32 Inch Holes, D
G
G
C
E
To Sewer
Wall
MIXER DIMENSIONS
A | B | C | D | E | F | G | H | TONNAGE
1" | 1¼" | 5" | 266 | AREA E = 4 X AREA B | 30" | 15 | | 3 to 25
1¼" | 2" | 6" | 460 | | 60" | 20 | | 26 " 60
1½" | 2" | 7" | 625 | | 70 | 25 | | 61 " 100
2" | 2½" | 9" | 1000 | | 90 | 30 | | 101 " 175
2" | 2½" | 9" | 1000 | | 90 | 30 | | 176 " 250
Note - for larger plants use additional mixers
C
Compressor
Compression Machine C
Pressure Imposing Elements
Absorption Machine A
Absorption Machine
Generator A
Absorber
F.E. Matthews

FIG. 1. REFRIGERATING SYSTEM, SHOWING VERTICAL MIXER

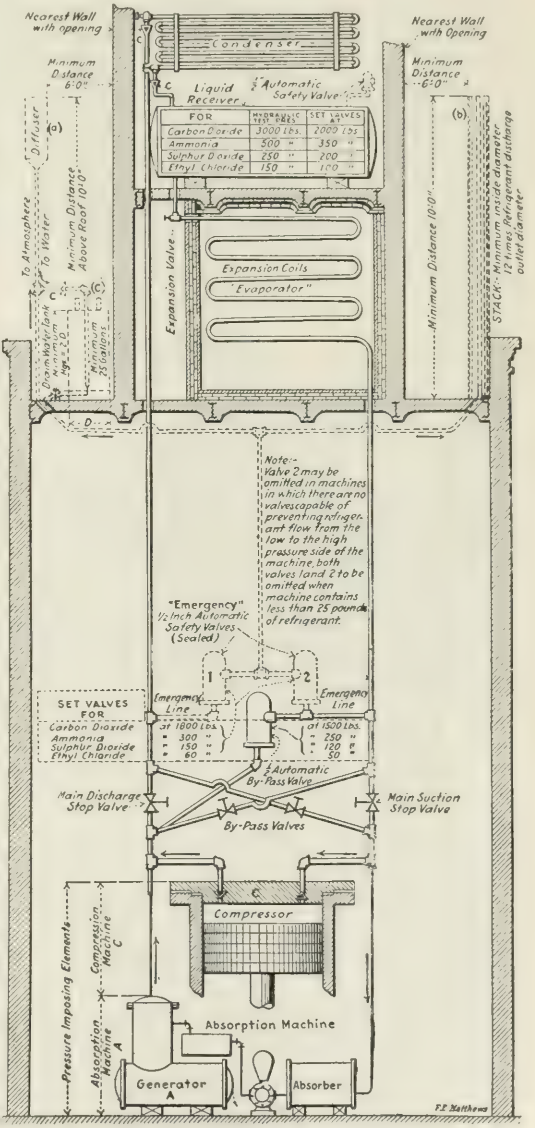

Nearest Wall with opening
Nearest Wall with Opening
Condenser
C
C
Liquid Receiver
½" Automatic Safety Valve
Minimum Distance 6'0"
Minimum Distance 6'0"
FOR | HYDRAULIC TEST PRES | SET VALVES AT
Carbon Dioxide | 3000 Lbs. | 2000 Lbs.
Ammonia | 500 " | 350 "
Sulphur Dioxide | 250 " | 200 "
Ethyl Chloride | 150 " | 100 "
Diffuser
(a)
(b)
To Atmosphere
To Water
Minimum Distance Above Roof 10'0"
Minimum Distance 10'0"
STACK - Minimum inside diameter 12 times Refrigerant discharge outlet diameter
Expansion Valve
Expansion Coils
"Evaporator"
C
(c)
Drain
Water Tank
Minimum Hgt. = 2 D.
Minimum D. 25 Gallons
D
Note:- Valve 2 may be omitted in machines in which there are no valves capable of preventing refrigerant flow from the low to the high pressure side of the machine, both valves 1 and 2 to be omitted when machine contains less than 25 pounds of refrigerant.
"Emergency" ½ Inch Automatic Safety Valves (Sealed)
1
2
Emergency Line
Emergency Line
SET VALVES FOR
Carbon Dioxide at 1800 Lbs. at 1500 Lbs.
Ammonia " 300 " " 250 "
Sulphur Dioxide " 150 " " 120 "
Ethyl Chloride " 60 " " 50 "
½ Automatic By-Pass Valve
Main Discharge Stop Valve
Main Suction Stop Valve
By-Pass Valves
C
Compressor
Compression Machine C
Pressure Imposing Elements
Absorption Machine A
Absorption Machine
Generator A
Absorber
F.E. Matthews

FIG. 2. CONNECTIONS FOR PLANTS UNDER THREE TONS CAPACITY

(b) Discharge of the refrigerants, ammonia, carbon dioxide, ethyl chloride or sulphur dioxide, to the atmosphere may also be effected through a ventilating stack, provided (1) that its inside diameter is not less than twelve times that of the refrigerant discharge outlet and (2) that the first possible outlet satisfies the requirements of paragraph (a) of this section, except that no diffuser is required.

(c) The refrigerant, ammonia, may be discharged into a tank of water, provided that the tank always contains one gallon of fresh water, not used for any other purpose, for every pound of ammonia contained in the machine, and provided, however, that in no case shall the tank contain less than twenty-five gallons of water.

(d) The refrigerant, ammonia, passed by the hand-operated emergency valves, may be discharged into the sewer after mixing with water in a suitable vertical mixer constructed and connected in accordance with Fig. 1 and provided with a standard Fire Department siamese connection through which the Fire Department shall supply the necessary water under the proper pressure.

The tank shall be substantially constructed with a hinged cover, or if it is of the inclosed type, it shall have an inlet and a vent hole at the top. No horizontal dimension of the tank shall be greater than one-half the height. The discharge pipe or pipes from the valves shall be so attached as to discharge the refrigerant at the center of the bottom. The tank shall be securely supported and braced as firmly as any other part of the system. There shall be a valve at the bottom of the tank for draining it.

SECTION 8

In such refrigerating plants as shall be designated by the Fire Commissioner, suitable helmets or respirators shall be kept, fit and available for the immediate use of responsible attendants who shall be trained in their use.

SECTION 9

In all refrigerating-machinery rooms in which ammonia or ethyl chloride is used there shall be no flames, arc lights, gas jets, or any apparatus employing flame, except internal combustion engines with hot surface ignition, which may be started in the usual manner.

SECTION 10

All rooms for refrigerating machines containing 25 lb. or over of refrigerant shall have a direct exit to the open air or to a room or hall from which gases can be excluded by self-closing doors.

Vertical and horizontal openings that permit the passage of gases to other parts of the building, which are not a part of the refrigerating plant, shall be sealed or provided with self-closing doors.

All refrigerating-machinery rooms shall be provided with adequate ventilation to the open air, either direct or by means of a suitable duct or ducts. Where mechanical systems of ventilation are employed, control of such systems shall be located at a point easily accessible in case of fire.

SECTION 11

Cylinders containing spare refrigerant shall be stored in a cool, well-ventilated place, as remote as possible from danger by fire.

Fires in Turbo-Alternators*

CONSIDERABLE attention has lately been and is now being given by member companies to the matter of fires originating within the generator shell of turbo-generators of the inclosed type with the object of (a) determining means of minimizing the occurrence of such fires, (b) limiting the extent of the damage to as small a section of the generator as possible, (c) providing fire-fighting equipment which can be applied quickly where it will be most effective.

In response to a questionnaire sent early in March to 64 companies operating generators of comparatively large size, replies were received from 30. The information received, recording experience of companies along the lines indicated, has been tabulated, compared and carefully studied and summed up as follows:

The total number of fires referred to by the 30 companies returning the questionnaire was 81, their occurrence being within the past three or four years. Twenty-one fires, about equally divided between 25- and 60-cycle units, were specifically described, occurring in units ranging from 3300- to 35,000-kw. capacity and 2300 to 13,200 volts.

The various fires have been attributed to many causes—about one-third of the number reported appear to be due to short-circuits between conductors and a greater number to grounds, while the remainder are divided among mechanical causes, eddy currents, corona and moisture from faulty operation or from freezing of air washing apparatus, condensation, etc.

The inspection and cleaning of turbo-generators at more frequent intervals would seem to be very desirable and to have a direct bearing on the liability to fires from sources external to the winding. Every precaution should be taken to limit the amount of dirt and oil which may enter the generator, and many companies, particularly on the larger units, have standardized the installation of air washers. Even with the best possible condition of cooling air, however, it is evident that dirt will lodge within the generator, and if a certain amount of oil vapor is also carried into the machine, the coil surfaces and other parts may become coated with grease. Good practice, therefore, would seem to indicate that machines should be opened up periodically for thorough cleaning and possibly for painting. There seems to be a wide difference in the practice of member companies with regard to the frequency at which such inspections and cleanings are made. It would pay to give attention to the matter of cleaning at least once a year.

One company feels that additional insulation on the armature coils of generators is as satisfactory a method of reducing the fire hazard as any that has so far been suggested. It is thought that this has a distinct advantage, and in some units it can be obtained for such a small increase in price that it may be the cheapest of all methods of reducing fire hazard. On two 35,000-kw. units for initial operation at 6600 volts, arranged for future operation at 11,000 volts, the manufacturer has guaranteed a high-potential test on individual coils of 40,000 volts and on the complete machine of 34,000 volts.

The grounding of the neutral of three-phase systems solidly or through resistance is rapidly becoming standard practice on both 25- and 60-cycle systems throughout the country. Of the thirty companies replying, 21 favored this method of operation, 5 preferred operating with solid ground and 16 preferred operating through resistance; 3 companies opposed the grounding of the neutral. The consensus of opinion seems to be that grounding is very desirable and, in addition to other advantages, has a considerable effect on the reduction of generator fires occurring external to the insulation of the copper conductors.

It is also rapidly becoming standard practice, particularly on larger units, for the manufacturer to bring out both ends of each phase winding to the generator terminal boards, so as to permit the installation of current transformers between the terminals of the phase windings and the neutral of the coils to operate a balanced relay. These current transformers can be connected differentially with respect to instrument current transformers in the leads between the main oil switch and generator, so that in the event of a fault in the generator or its leads the balanced relay will immediately open the main oil switch, the neutral switch, if closed, and after a slight delay the field switch. Twenty-four of the thirty companies reporting approve the installation of balanced-relay protection and have adopted it as standard practice on all new-generator installations and on older generators where the expense involved is not too great.

In 1912 one company installed balanced-relay protection on tie-line cables between two near-by generating stations, and their operation was so successful as to lead to a willingness for trial installation of balanced relays on a generator being installed in 1914. From that time on this equipment has proved very satisfactory and has been extended to all new machines on that system. It is now being rapidly adopted by other operating companies. The best evidence of the value of this protection is furnished in the reports of generator failures on which this protection was employed.

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*Abstract from the report of the subcommittee on generators, presented in the report of the Committee on Electrical Apparatus, at the National Electric Light Association Convention, held in Atlantic City, May 19-22, 1919.

On a 25,000-kw. unit there have been three armature-coil failures in the last three years, on all of which occasions the balanced relay operated, and on two occasions the damage was confined to the coil where the breakdown occurred. A slight amount of damage occurred to the laminations in one of these instances, not sufficiently severe, however, to necessitate restacking. At the time of the third failure mentioned, the field switch failed to open, owing to defective operation, the iron and the coils of the upper half and the insulation on the end connection at one end of the lower half were badly damaged. It was necessary to restack the iron and to rewind the upper half of the armature and to reinsulate the field completely. There is every reason to believe that, had the field switch opened properly, the damage would have been confined to the coil where the breakdown occurred, thus very greatly reducing the cost of repairs.

Another company installed balanced-relay protection on the leads of four 15,000-kv.-a. generators in 1913, and after some cases of successful operation of such relays on generator-cable trouble, it decided in 1916 to extend the protection to the generator windings as well on all new units. Several instances of successful operation during trouble on both generator windings and leads have occurred since, testifying to the value and reliability of this protection.

In the methods thus far adopted for extinguishing electrical fires, water, steam and carbon tetrachloride have been used. Water and steam are looked on at present with favor.

Up to the time of the installation of permanent fire extinguishing apparatus for generators, water, because of its greater availability over steam, has been the principal medium for extinguishing, where Pyrene was ineffective. Experience has demonstrated, however, that it is extremely difficult to put out a fire in the generator before extensive damage has occurred without applying water directly at the seat of the trouble. In many cases reported it has been necessary to remove the end bells and direct the water stream on the windings.

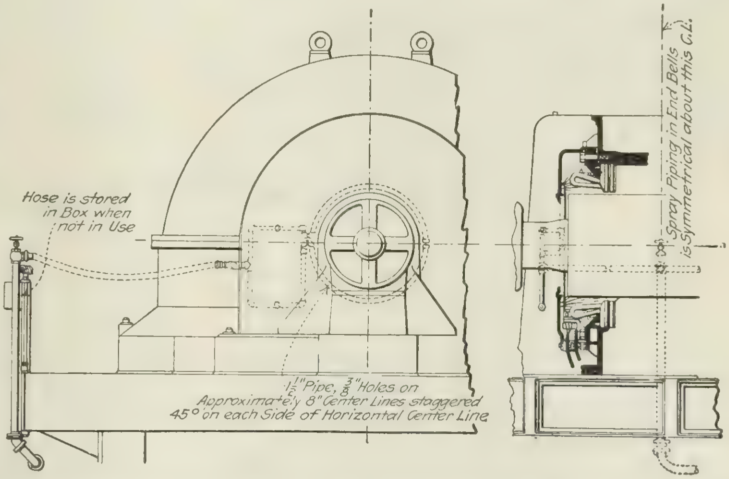
With the advent, however, of permanently installed fire-extinguishing provisions in generators, the use of steam has received very serious consideration, and there is at the present time a wide difference in opinion as to the relative merits of water and steam for this purpose. Of the 30 companies reporting, the use of water is definitely favored by 9 and opposed by 8, and the use of steam favored by 7 and opposed by 12; 18 generators of 4 companies are now provided with permanent steam equipment, as against 9 units of 3 companies with water equipment.

The principle of operating in using steam differs from that in using water primarily in that displacement of air in the generator by steam is very largely depended upon to smother the fire. It is extremely important, however, in using steam to shut off the supply of air to the generator as completely and promptly as possible, and some means of facilitating this operation should be provided. It would seem that the air damper could be placed more effectively in the outlet rather than the inlet wherever the design permitted. The wetting of the generator windings from condensed steam may also be helpful. In using water, the idea is to wet the windings as far as possible, this being aided by the natural ventilation of the machine.

The possibilities of liquid carbon dioxide or other noncombustible gases or liquids have also been discussed, but no advocates of these materials have been found

For the ready application of water to the generator windings the usual practice is to provide pipe rings, which are fastened at each end of the generator inside of the end bells. Perforations are located in these pipes so as to throw a fine spray of water over the entire winding and over the air gap between the armature and field. The pipe rings are then connected together into a reliable source of water supply under the desired pressure. The figure shows the general arrangement of this type of installation. The natural ventilation of the machine helps to spread the water over the entire winding. For the ready application of steam to the generator windings two methods have been used: (1) Steam pipe arranged inside the end bells, perforated so that numerous jets will impinge directly on the end portion of the windings and into the air gap in practically the same way water is used; (2) location of a perforated steam pipe in the air inlet of the generator.

In both of these cases the steam supply is obtained from the branch-system mains supplying the auxiliaries of the unit protected. The second plan has been adopted by some companies because of a fear that the steam may have a deteriorating effect on the insulation when it impinges directly on the end turns as in the first plan. In applying steam it is the rule of one company that the valve be opened for two-minute intervals, additional applications being given only if the fire continues.


Hose is stored in Box when not in Use
1½" Pipe, ⅜" Holes on Approximately 8" Center Lines staggered 45° on each Side of Horizontal Center Line
Spray Piping in End Bells is Symmetrical about this C.L.

LOCATION OF WATER PIPES FOR EXTINGUISHING FIRES IN GENERATORS

Some few fires have occurred from mechanical causes alone, such as fan rubbing against end bells, producing red-hot surfaces. These have led to an installation of glass windows in generator end bells by at least one company for indication of such trouble. The advisability of using similar windows at the side of the base is worthy of consideration.

Before proceeding to fight any generator fire, it is, of course, absolutely essential that the unit be disconnected from the line and the field opened. With balanced-relay protection, this is done automatically when fires involve a breakdown from the copper conductors on a grounded system.

It will be necessary after application of water to the generator's windings to dry them out before placing in operation again. Experiences have demonstrated that electrical generators may be sprayed with water for some time with no serious damage resulting, if they are thoroughly dried out before being again placed in commission.

Some companies opposed to the use of steam have expressed fear regarding the possibility of detrimental effects of high temperature on the insulation, particularly where steam is applied for a long period of time or where it impinges directly on the windings. The destruction of the japanning on the core laminations by the high temperature is also feared. The Duquesne Light Co., however, has had several fires since installing perforated steam pipes in the air inlet of its machines and reports satisfactory results.

Nearly all of these fires were started external to the winding and were extinguished with one two-minute application of steam. On all but two occasions the generator was restored to service without being dried out, having been out of service only from three to four hours, and in one other instance the drying out was done simply by rotating the machine for about seven hours without short-circuiting the windings or exciting the field. One fire, starting from a ground, developed into a short-circuit, but on only a few coils was the insulation burned sufficiently to necessitate replacing them. This machine was entirely rewound, however, as it had been through a previous fire and was not in the best of shape. It appears, however, that the equipment installed by this company has not, as yet, had an opportunity to demonstrate satisfactorily its ability to handle severe fires, and until more experience data with such fires are available no definite conclusions should be drawn.

In one instance it was reported by a Western company that steam used for fighting a fire destroyed the japanning of the lamination and therefore made necessary the entire dismantling of the generator armature. Yet the same company has shown its faith in steam for this purpose by installing this means of fire extinguishing in its generator installations.

The Public Service Company of New Jersey recently applied steam unsuccessfully to a very severe fire. No companies using a water system have, as yet, had occasion to try it, so that all arguments in its favor are merely opinions or deductions.

The conclusion is reached that according to the information received several serious generator fires have occurred in turbine-driven units of various sizes, voltages, speeds, frequencies and manufacture. These fires have originated within the generator shell from a variety of causes and have been in many instances very difficult to extinguish before extensive damage has been done.

In order to lessen the probability of the occurrence of such fires, it is suggested that constant consideration be given to the cleanliness of generators.

In order to minimize the extent of damage from fires, it has been found advisable in many cases to install balanced-relay protection on turbo-generators, to automatically disconnect the unit from the line and open the field. This practice seems sound and manufacturers are urged to standardize upon the bringing out of both ends of all phase windings to generator terminal boards on all units of 5000-kw. capacity and larger, and also on smaller sizes where no appreciable increase in the selling price of the unit will result.

The practice of installing some form of permanent fire-extinguishing equipment is gaining considerable headway and is being adopted by many companies. The substance to be used should be water or steam, the weight of opinion and practice, to date, being in favor of water, although actual experience with specially provided equipment has been obtained thus far only with the use of steam, and that by the Duquesne Light Co. to its entire satisfaction.

Operators who have installed or who shortly will install any regular means of extinguishing fires are urged to keep a careful record of all circumstances of their experience for the benefit of the industry.

Central-Station Heating in Detroit*

By J. H. Walker†

Discusses the general problem of the utilization of the heat ordinarily discharged to the condensing water in a central electric generating station. The impossibility of its complete utilization for the purpose of heating buildings and the difficulties in the way of even its partial utilization are pointed out, with particular reference to conditions existing in Detroit. The development of the central heating system of the Detroit Edison Company is traced, showing how the use of exhaust steam for heating was abandoned in favor of live steam.

The heat carried away by the condensing water in the central electric stations of the United States, equivalent to about 60 per cent. of the total fuel burned by them, is one of the more obvious, although not by any means the greatest, wastes of the country's resources. Like many other similar losses this one exists, not because its reduction is theoretically impossible, but because it is seldom commercially practicable.

This great quantity of heat, rejected at low temperature from the generating units, may be considered as a byproduct of electricity supply and as such its rate of production will depend upon the rate of production of electricity, the primary product. The complete utilization of any byproduct becomes possible only when an outlet for it exists or can be created. Moreover, since neither electrical energy nor heat can be stored to any great extent, it is necessary for the complete recovery of this byproduct that the demand for it be equivalent, hour by hour, and day by day, to the rate of electricity supply. The warming of the interior of buildings is of course a natural means of utilizing this heat, but the great diversity in the rate of use of the two commodities renders impossible even an approximately complete realization of the theoretical economy. The lack of agreement in their use from week to week throughout the year is illustrated in Fig. 1, in which the 1918 load curves for electrical and heating service in Detroit are plotted to a percentage scale with the maximum point on each curve taken as 100 per cent.

Another important obstacle to the full use of this byproduct heat through the warming of buildings is due to the great development of the central electric stations, which in many industrial centers in the United States have so increased in size that the amount of exhaust heat which would be available as a byproduct is greatly in excess of that which it would be commercially feasible to distribute for the heating of buildings. For example, in 1918 the central electric-generating stations in Detroit produced approximately 774,000,000 kw.-hr. of electricity. The exhaust steam that would have been available if discharged at pressures above atmosphere and which could have been utilized for heating, considering the winter months only, would have amounted to over 9,000,000,000 lb. This is five times the quantity actually distributed in the existing central heating system of the city, which entirely covers the only portion of the city in which the heating load is sufficiently dense to render the laying of distribution mains commercially justifiable. For because of the great investment costs the distribution of heat by the medium of steam is feasible only in the districts of relatively great density of load, which in most of our cities, comprise only the business district and the very best residence districts. Nor are the economies to be gained by using byproduct heat sufficient to enlarge this area appreciably. The central heating business in the average American city could keep pace with the electricity-supply business only if the density of population were far greater than is compatible with present standards of living.

Assuming that a central heating load exists and is to be supplied by the electric company, there are in general three methods by which this can be done:

1. The heating load can be observed from a condensing

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*Presented at Spring meeting of the American Society of Mechanical Engineers, Detroit, June 16 to 19.

†With the Detroit Edison Co., Detroit, Mich.

generating station so designed that steam is available for heating at pressures above atmosphere after partial expansion in the electric-generating units, the remainder of the steam used for current generation being fully expanded and condensed at high vacuum.

2. Separate heating plants may be built in locations near the heating load and equipped with noncondensing generating units which will generate current only to the extent of the requirements for exhaust steam for heating, the remainder of the electricity being produced in a condensing station.

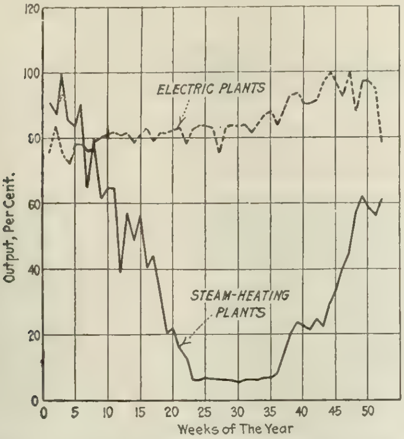


FIG. 1. LOAD CURVES OF ELECTRIC AND STEAM HEATING PLANTS

3. The heating system may be supplied entirely with live steam from boiler plants located near the center of the heating load.

It may so happen that the natural location for the main generating station serving a city is near the heating load, and if this is the case, the first method is preferable. Often, however, a consideration of land values or of railroad connections requires that the main condensing station be located at such a distance from the heating load as to preclude the possibility of transmitting steam from it. This is the case in Detroit. The Delray plant and the Connors Creek plant, the two main generating stations operated by the Detroit Edison Co., are respectively 3½ and 4½ miles from the heating district. A condensing plant, located on high-priced land near the heating district and with inconvenient railroad connections or none, would be necessary if this first method were to be used. To such a plant, built for electricity supply and consequently, for reasons previously stated, burning more coal than a plant built solely for heating, this matter of proper railroad facilities is particularly important. Here again enters the matter of the transmission of steam, for the size of the pipes required to transmit a given quantity of steam over a given distance decreases as the density of the steam and the amount of pressure drop along the pipe increase. The most economical method from the standpoint of investment costs would be to extract steam from the high-pressure stages of the turbine; but the amount of electricity which could be generated per pound of steam would be reduced.

DEVELOPMENT OF CENTRAL HEATING IN DETROIT

The immediate motive which, in 1903, led to the establishment of the central heating industry in Detroit was the possibility of obtaining a high thermal efficiency in the generation of electricity through the utilization of the exhaust steam, but the actual over-all economy of the plant was not as great as had been anticipated.

A year later the construction of a central heating plant was begun in the business district of the city. This second project was undertaken, not as a means of disposing of exhaust steam, but for the express purpose of supplying the demand for central heating service among the owners of downtown buildings who were considering shutting down their plants and purchasing electric service. The downtown plant was built primarily as a heating plant, and though provision was made for electric generating units, they were never installed and the heating mains were supplied with steam from the boilers through reducing valves.

With the development of the large condensing generating stations the generation of current in the heating plants grew less and less attractive, and when a third heating plant became necessary because of increasing demand for steam heat, no provision was made for electric generators. The same practice was followed when, in 1916, the original exhaust-steam plant was rebuilt; and when the steam-distribution system of another company which had been engaged in the generation of electricity and the distribution of exhaust steam in the business district was purchased by the Detroit Edison Co., the new plant which was built to supply this district was also designed as a heating plant only. The entire combined distribution system is now being supplied with live steam from the boilers through reducing valves.

Since there are no generating units exhausting into the heating system, the pressure carried on it is not limited by considerations of back pressure. On those sections of the system formerly supplied with exhaust steam at from 2 to 5 lb. pressure, the pressure now maintained ranges from 5 to 15 lb. and is being increased from year to year, toward the upper limit permitted by the strength of the pipes. The pressure on the section originally designed as a live-steam system is about 30 lb. Because of the increased capacity of the distribution system at higher pressures, due to the greater density of the steam and the greater allowable pressure drop, these higher distribution pressures are desirable.

REASONS FOR USING LIVE STEAM IN DETROIT

The supplying of live steam to the heating system and the abandonment of the generation of current in the heating plants is commercially justifiable, even though such current would be generated at a high thermal efficiency. The underlying reason for this is that there exist certain unfavorable conditions which outweigh the thermal advantage and make the total cost of such current higher than the generating cost at the large and efficient main generating stations.

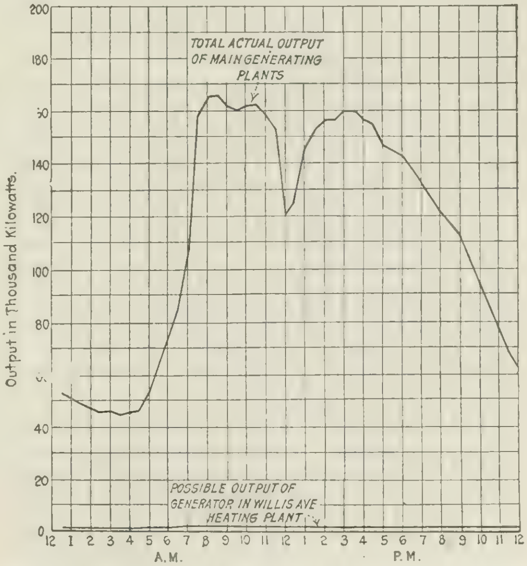


FIG. 2. LOAD CURVES SHOWING POSSIBLE ELECTRIC OUTPUT OF HEATING PLANT COMPARED WITH OUTPUT OF MAIN STATION

In consideration the cost of generating current, when the heat in the exhaust is recovered, it should be borne in mind at the outset that the amount of coal consumed, though small, is not by any means negligible as compared to that consumed in a condensing station. For each kilowatt-hour so generated, there would be extracted from the steam, if the conversion were 100 per cent. efficient, its heat equivalent, 3415 B.t.u. Taking into account mechanical and electrical losses in the generating unit and the losses involved in generating steam from the coal, the actual number of heat units devoted to the generation of electricity is not less than 5700 B.t.u. per kw.-hr. This is 27 per cent. of the corresponding figure for the Connors Creek plant (a condensing station) which in 1918 generated its total output at an average of 20,900 B.t.u. in the coal per kw.-hr. of output. So that at the outset the additional fuel that would have to be burned in the heating plants if current were generated, would be over one-quarter of the amount required to produce the equivalent amount of current at the Connors Creek plant.

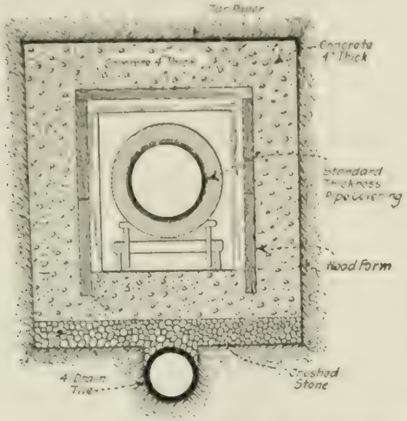


FIG. 3. UNDERGROUND STEAM LINE CONSTRUCTION

One of the principal elements of cost, which militates against current generation in the heating plants, is the attendant labor, which, because of the low load factor and small size of any generating units that might be installed there, makes the cost of this item per kilowatt-hour generated much higher than in the large stations where the size of the units and the load factor are much greater.

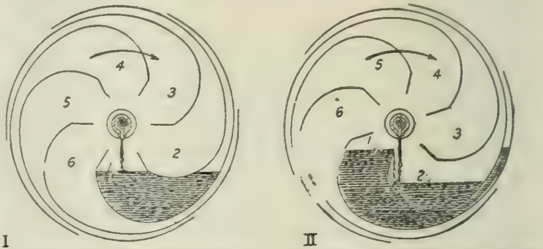
But the deciding factors are the investment charges. The change of policy involving the final abandonment of exhaust-steam heating was made in 1916, with the rebuilding of the Willis Ave. heating plant, the original exhaust-steam plant. At this time the electrical load in Detroit was increasing rapidly and several new turbine-generator units were being purchased. At the Willis Ave. heating plant the existing and future exhaust-steam requirements would have called for a generating unit of about 2000 kw. capacity. The unit purchased at the time for the Connors Creek plant was the 45,000-kw. machine which has since been put into service. Would the existence of small generating units in the heating plants, aggregating altogether possibly 4000 kw., actually reduce the number of machines in the Connors Creek plant at that time or at any future time, if the latter were to increase in steps of this magnitude? Regardless of theoretical considerations, as a matter of fact it actually would not have done so and it became clearly evident, therefore, that any investment in generating units in the heating plants must be reckoned as *additional* investment, and the cost of any electricity generated by them must include the fixed charges on that investment and could not be credited with having saved any investment elsewhere. The relatively insignificant proportion of the total system load which could be borne by a unit in the Willis Ave. plant is strikingly illustrated in Fig. 2.

In accordance with the considerations that have been mentioned, the proposed turbo-generator installation should be charged with its operating and maintenance costs including, labor, supplies, and the fuel equivalent of the energy produced. It should also be charged with the fixed charges on the unit itself and on the building space occupied. Based on the fairly stable pre-war prices existing in 1916, these items might be conservatively estimated as follows, neglecting the disadvantage due to the lack of coördination between steam and electrical loads.

Charges Against Generating Unit—Operation and Maintenance		
Labor—3 oilers		$3,360
Supplies, etc.		200
Fuel cost—1221 tons at $2.66		3,247
Maintenance		200
		$7,007
Fixed Chaarges (Additional Items Only):		
2000-kw. turbo-generator at $15 per kw.	$30,000	
Installation cost, wiring and piping	4,000	
Building and foundations	10,000	
	$44,000	
Depreciation at 4 per cent.		1,760
Return on investment at 6½ per cent.		2,860
Total charge against turbine		$11,627

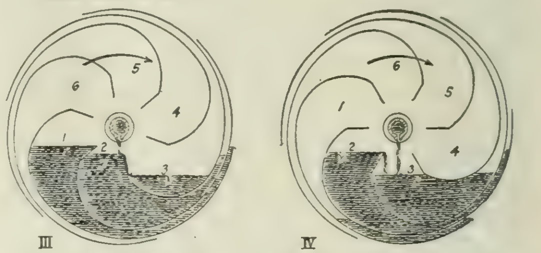
The turbo-generator must of course be credited with the cost of generating an equivalent amount of energy at the main plant, of transmitting it to the heating-plant district and of converting it to direct current, since these costs would be incurred if the turbo-generator were not installed.

The production cost of electric current generated by a central station consists of two parts, the demand or "readiness to serve" component and the "energy" component. The former may be defined as that portion of the total production cost that would be incurred if no electricity were actually delivered, but if the plant were merely held in readiness to deliver the loads actually sustained; in other words, with steam pressure up, turbines and auxiliaries in motion, a sufficient number of boilers banked and the operating crew on duty. The energy component may be considered as that part of the total cost which is directly proportional to the amount of energy delivered. Although the exact separation of these components is impossible, the distinction between them is none the less real and is one that is generally recognized.



I Compartment No. 1 Filling. Water Extending to Right of Center Turns Drum in Direction of Arrow

II Compartment No. 1 Filled and Overflowing into Compartment No. 2.



III No. 1 Ready to Empty No. 2 Full and Overflowing into No. 3.

IV No. 1 Nearly Empty. No. 2 Overflowing and No. 3 Nearly Full

FIG. 4. CONDENSATION METER AND ITS PRINCIPLE OF OPERATION

In the present case the heating-plant generating unit can be credited only with energy component, since it is not to be considered as having reduced the size or number of units in the main generating plant. The energy component may fairly be considered as including 75 per cent. of the fuel cost, 50 per cent. of the cost of maintenance of plant equipment and that part of the labor such as coal handling which would be generated at Connors Creek 7,500,000 kilowatt-hours.

The credit which can be allowed to the heating plant for the current which it would generate would then be as follows:

Fuel—4112 tons at $2.38	$9,786
Wages	285
Maintenance	617
Total credit allowable	$10,688

This credit of $10,688 compared with the larger figure of $11,627 which is to be charged against the heating-plant unit, thus indicates that the generating of current in the heating plant would not be justified.

The foregoing study, however, is based only upon conditions in the plant itself, and no mention has been made of the effect upon the distribution system when exhaust steam is distributed.

The method of live-steam operation was adopted in Detroit before the recent great advance in the price of coal. The present price of coal makes exhaust-steam operation appear somewhat more favorable and it is of course conceivable that at some future date a high coal price may compel a change of policy. But with the cost of underground lines also increasing, the saving in distribution investment will probably continue to be sufficient to justify a continuation of the present methods.

The four boiler plants in Detroit which supply steam to the heating system are equipped with water-tube boilers and underfeed stokers and are of modern design throughout. The Congress St. plant, the newest of the four, is designed to eventually contain four 1300-hp. boilers and two 2600-hp. boilers of the "W" type. In the effort to reduce the amount of attendance labor at this plant, the auxiliaries are located for the most part on the boiler-room floor so as to be within convenient reach of the few men constituting the operating crew. Coal is hauled from bunkers at the railroad sidings to the plant in drop-bottom buckets of 5 tons capacity, which are lifted by a crane and emptied into overhead hoppers from which the coal is distributed by belt conveyors to the boiler bunkers. Ash-handling equipment is practically nil, the boilers being set at sufficient elevation to allow wagons to be driven beneath the hoppers.

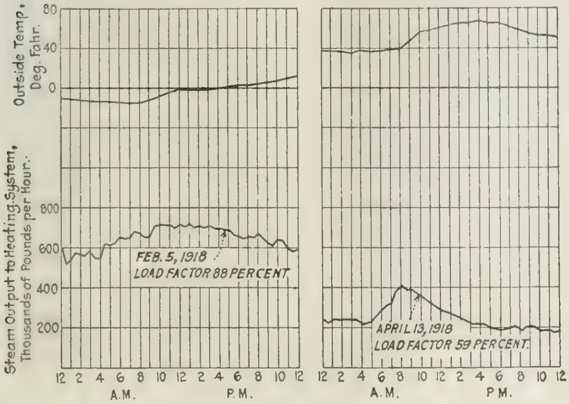


FIG. 5. TYPICAL LOAD CURVES OF HEATING SYSTEM

Because of the fact that only a relatively small amount of condensation is returned to the plants, careful treatment of the raw water is necessary. The feed water flows through live-steam purifiers, operating at boiler pressure, in which the scale-forming materials are precipitated. In addition, sodium carbonate is fed in automatically graduated amounts to reduce the slight amount of hard scale-forming material that finds its way into the boiler. Although Detroit water is not a bad boiler water, these precautions are necessary because of the large percentage of makeup water and the rather high rates of steaming at which the boilers are sometimes driven.

Steam is generated at a pressure of 130 lb. gage. This pressure is chosen in order to provide for considerable pressure drops in the outgoing feeders as calculated for present conditions. It may be raised to 160 lb. at some future date. The outgoing steam lines leave the plant through a tunnel shaft.

The popularity of the heating service in Detroit has led to its development on an extensive scale. The present distribution system covers an area of about two miles long and half a mile wide, which includes the entire central shopping, business and financial districts and a small portion of the residence district. About 2,700,000 sq.ft. of radiation, besides numerous water heaters and cooking fixtures, are served. The distribution system contains about 20 miles of underground mains and 2 miles of tunnels. The four boiler plants that supply steam to the system contain 17,470 rated boiler hp., and they delivered in 1918 nearly two million pounds of steam to the system.

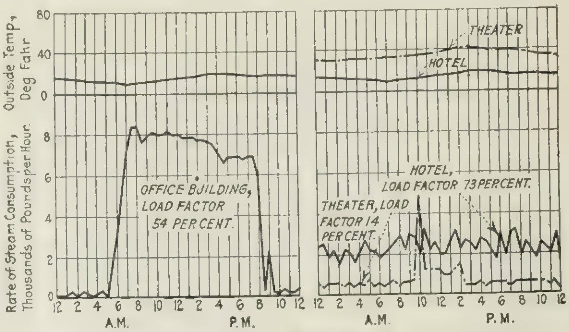


FIG. 6. TYPICAL LOAD CURVES OF INDIVIDUAL CONSUMERS

The distribution mains, though originally built in three distinct sections, are now a practically continuous network and the plants are so much interconnected that the load can readily be shifted from one to another. In spring and early autumn two of the four plants serve the entire area.

Because of the great increase in connected load the transmission capacity of the distribution network, most of which was installed several years ago, is now quite inadequate. To have raised the pressure throughout the system would have increased its capacity; but the system pressure was permanently limited by the fact that most of the underground fittings are of a low-pressure pattern, and temporarily by the fact that in those sections of the system formerly supplied with exhaust steam the customers' installations are not provided with reducing valves. Instead of attempting to change these conditions, which would have involved the reconstruction of much of the distribution network, the less expensive plan was adopted of running feeders from the plants to various centers of distribution.

The velocity of the steam flow in feeders at times of heavy load is very high. Velocities as great at 75,000 ft. per min. have been measured. This high velocity does not appear to be at all obectionable, however, there being no apparent erosion of the pipe and no hammer, or objectionable vibration.

The distribution mains range in size from 20 in. near the stations to 4 in. at the outskirts of the system. The original underground pipes were laid in a segmental wood casing bound with wire. This construction has been fairly successful under favorable soil conditions, but the concrete conduit shown in Fig. 3 has been found to be superior in many respects and has been used exclusively for several years in all new construction.

In the heart of the business district the pipes are in tunnels, of which there are about two miles, lying from 25 to 40 ft. below the street level. In cross-section they are similar to a horseshoe and are built of brick, with concrete floors. For the most part they are about 6 ft. in height and 6 ft. wide. The tunnels are ventilated by suction fans which draw a small amount of air through them continuously and a much larger amount when it becomes necessary for men to work in the tunnels. The temperature ranges between 90 and 130 deg. F.

Important to Disabled Men

In his work throughout the country in behalf of discharged service men, Col. Arthur Woods, Assistant to the Secretary of War in charge of finding employment for demobilized soldiers, sailors and marines, has learned that in many sections people generally do not know just what the Government is doing to enable men disabled in the line of duty to reëstablish themselves in civil life.

Inasmuch as the Government took these men out of civil life and placed them in camps and in the trenches where their disabilities were incurred, the obligation upon the Government to reëstablish them in civil life is clear. And it should be understood that those injured in France are not the only ones entitled to assistance, for all disabled service men, whether injured in the United States or abroad are provided for equally.

For reëstablishing the disabled in civil life, the authorized agency of the Government is the Federal Board for Vocational Education, which is charged by Congress with the "vocational training of disabled soldiers and the placement of rehabilitated persons in suitable and gainful occupations," after their discharge from the Army.

In some large cities crippled men in uniform are seen on the street engaged in "panhandling" kindly disposed persons. It has been found that in nearly every case these men were just plain ordinary fakers in the guise of soldiers, who took this method of enlisting unmerited sympathy from the public. There is no excuse for these fakers. No man disabled in the service need engage in any sort of holdup game in the streets nor need he engage in any occupation whatever which is not becoming to him. Anyone seeing men in uniform so engaged should inform them of provision made for their training and placement by the Government. If any man, after being informed what his opportunities are, continues his game, a favor will be done the great body of self-respecting disabled men who are trying to make something of themselves if every case of this character is reported to the nearest branch office of the Federal Board for Vocational Education.

If any disabled service man who is considered by the Bureau of War Risk Insurance to be as much as 10 per cent. disabled will get in touch with the Federal Board for Vocational Education, Washington, or with any one of its fourteen branch offices (locations given below), the Federal Board will place them in educational institutions, when education is necessary and feasible, where suitable trades or occupations will be taught them according to their individual experience, capacities and preferences. A disabled man so incapacitated that he cannot take up his old occupation will be allowed to choose any occupation or trade that he thinks he would like to follow, subject, of course, to approval by the Federal Board, which is interested only to be assured that the man is fitted to pursue the occupation or trade elected.

District No.	States Covered	Office
1	Maine, New Hampshire, Vermont, Massachusetts, Rhode Island	Room 433, Tremont Building, Boston, Mass.
2.	Connecticut, New York, New Jersey	Room 711, 281 Broadway, New York City
3	Pennsylvania, Delaware	1000 Penn Square Building, Philadelphia, Penn.
4.	District of Columbia, Maryland, Virginia, West Virginia	606 F St., N. W., Washington, D. C.
5	North Carolina, South Carolina, Georgia, Florida, Tennessee	Candler Building, Atlanta, Ga
6	Alabama, Mississippi, Louisiana	822 Maison Blanche Annex, New Orleans, La.
7.	Ohio, Indiana, Kentucky	906 Mercantile Library Building, Cincinnati, Ohio
8	Michigan, Illinois, Wisconsin	1600 The Westminster, 110 S. Dearborn St., Chicago, Ill.
9.	Iowa, Nebraska, Kansas, Missouri	517 Chemical Building, St. Louis, Mo.
10.	Minnesota, North Dakota, South Dakota	Room 742, Metropolitan Bank Building, Minneapolis, Minn.
11.	Wyoming, Colorado, New Mexico, Utah	909—17th St., Denver, Colo
12.	California, Nevada, Arizona	Room 997, Monadnock Building, San Francisco, Calif.
13.	Montana, Idaho, Oregon, Washington	Room 539, Central Building, Seattle, Wash.
14.	Arkansas, Oklahoma, Texas	810 Western Indemnity Building, 1000 Main St., Dallas, Tex.

While in training a man receives an amount equal at least to the base pay received during his last month's service in the Army, Navy or Marine Corps, but in no case does he receive less than $65 per month if a single man or less than $75 per month if living with his dependents, or less than $65 per month for himself if living apart from his dependents—in addition to allowances to his dependents if married and living apart from his wife during the period of training. In all cases the wife receives $15 and each minor child $10 per month. These payments are made to enable the man to support himself while in training, and are in lieu of subsistence, etc.

Under the arrangement first mentioned, if a man who served as a private at $30 per month wishes to take training, waiving claim to subsistence, clothing, etc., he will, if single or living apart from his dependents during training, be allowed an additional $35 per month by the Federal Board, thus bringing his income up to the minimum of $65 per month. Should the man have been a noncommissioned officer during his last month's service and have received as high as $81 per month, he will then continue to receive such pay and it will, of course, not be necessary in this case for the Federal Board to allow him anything additional. In the case of officers, it will be apparent, no allowance will be forthcoming from the Federal Board. Men who have been blinded in battle or who have lost both arms or both legs, or who as a result of injuries incurred are permanently and totally disabled, it may be noted, come under a special provision which allows them $100 per month additional.

Many crippled soldiers were discharged without being informed of the provisions made for them through the agency of the Federal Board, because they were released from service before the machinery for reaching them was in effect. Any person coming in contact with such disabled men will be doing a patriotic duty by directing them to write to the Federal Board at Washington or to one of the Board's fourteen branch offices, or, better yet, to appear in person at one of these offices if they can.

How the Business Press Serves Industry

In an address before the Pan American Commercial Conference at Washington, D. C., June 6, A. C. Pearson, president of the Business Publishers' Association, gives some interesting facts concerning the mission of the business paper. He has divided the publications into two general groups; namely, trade papers, which have to do with the sale and distribution of merchandise, and technical papers, such as engineering publications, which devote themselves to one particular science or profession. An abstract of Mr. Pearson's address follows:

The outstanding feature of a business paper is that it confines itself to business subjects and handles only those subjects which apply to its own trade or industry. The subscribers to business papers are interested in both the editorials and advertisements since they take these publications for the serious purpose of getting information and assistance in their particular occupation and all the contents bear directly on their business or profession.

Experts on world commerce have stated that they could tell the progress of a nation in any line by inspecting its business papers in that particular line, and any country wishing to progress in a particular industry might well invest a large sum in the improvement of its publications in that particular industry.

To get a commercial understanding and to promote the interchange of trade, it is necessary to read the same publications and adopt the same general business practices. It is most encouraging, therefore, that large numbers of the leading business papers in the United States are producing foreign editions and that many leading Latin American publications are getting editorial information and extensive advertising from the United States.

The business paper's first service to commercial intelligence is in its news of the markets, of the merchandise developments of the trade, or of the scientific progress. Its second service is that of advice and criticism. One prominent trade publication has as its motto, "What To Buy and How To Sell It." It devotes as much time and attention to the subject of selling merchandise as it does to the markets and the changes which will affect the price or desirability of merchandise.

A third great service rendered by the business publication is the advertising which it brings to the subscriber. In this is included the best offerings in the briefest possible form of the merits and talking points of the merchandise which that particular subscriber is interested in.

The leading business papers go into all the problems and the needs of their industry. They are the leading agitators for progress and frequently the unsparing critics of trade abuses. They take a leadership in advocating necessary legislation for the improvement of industry and are leaders in all broad, helpful and patriotic movements.

For example, the "MADE IN U. S. A." campaign was originated by a business paper. The great prosperity campaign now running is the result of the coöperation among some leading business men and business papers. The present Webb-Pomerene bill, which promises so much for foreign trade in the United States, was made possible largely by the coöperation and agitation of the business press. The fact that the Unted States Government secured its advertising free during the war, instead of paying out millions of dollars to publications, was due to the fact that three hundred business papers came forward and volunteered their space without charge to the Government for the duration of the war.

Since efficient service is based first on proper information, it will be necessary that the business papers make a thorough study of foreign conditions and that they equip themselves to show editorially the changing market requirements of the different countries to which their manufacturers wish to appeal. This rule applies to the Latin American publications in the same way that it applies to those of the United States.

The success of the trade between our respective countries will depend on the knowledge we have of the markets and requirements of our customers, wherever they may be. This information can be given primarily by the business press, and there is every indication that these publications are thoroughly alive to the responsibility which they owe their industry as well as their country.

Illinois N. A. S. E. State Convention

In Decatur, June 4-6, the Illinois State Association of the N. A. S. E. held its fifteenth annual meeting. There was a good attendance, exhibits were numerous, and at the meetings the enthusiasm needed to build up the various locals of the state was in evidence. The opening session was held Wednesday afternoon, with the local president, Frank Velton, in the chair. Mayor Borchers welcomed the engineers and John McGrath, past national president, responded. The mayor had made a plea for all to show their Americanism in these disturbing times. He was assured that the engineers had done so and would continue. Last year their strong effort had been on conservation. In the reconstruction period now on they would be called upon to meet the changes in the profession.

Porter J. Millikin, president of the Association of Commerce, dwelt upon community coöperation and the necessity for each one to do his part for the public good, to be part and parcel of the community in which he lives, to vote and to instill in the foreigner the true American spirit. National Secretary Raven added to the previous theme that doing one's work in the most efficient way possible is also one of the requirements of good citizenship. For 36 years the association had stood for education.

"Closer Relations Between the Engineer and Manager of the Plant" was a topic on which John Lane gave an interesting discourse. The engineer who is successful in these days gives much of his attention to the human side of engineering. He is liberal to those under him, knows the value of a smile and has become a student of psychology. The shortest path to success is to make a study of the manager, establish a good understanding, gain his confidence, and present results obtained in the plant in the simple form understood by the manager. He wishes to know the amount of service he is getting and what it costs him. Technical data and details will serve as a reference to the engineer when he is asked to explain the reasons why. To operate the plant successfully it is essential to make a close study of the manufacturing end of the establishment. The engineer cannot give best results without knowing what the plant services are used for and the requirements, and he should know costs in terms of the manufactured product.

John F. Alt, state president, was introduced, the convention officially opened, and the usual committees appointed.

On Wednesday evening the employers of engineers had been invited to learn what the association was doing and to look over the numerous exhibits. The program was partly impromptu, but under the general guidance of Fred Raven was a marked success. President Alt and W. H. Jennings, chairman of the local committee, spoke briefly. Charles Fiske said a few words in behalf of the exhibitors and Charles Cullen expressed his optimism over indications of an exceptionally good convention next fall. W. E. Harris, state deputy, said that in addition to the educational efforts the fraternal spirit so plainly in evidence contributed to the success of the organization.

Being in particularly good voice, Fred Hickey rendered several choice selections. Joe O'Connell voiced his approval of inviting manufacturers to the meeting so that they would become acquainted with the character of the engineer's work and recognize his ability and loyalty. It is a short cut to a better understanding that will eventually result in better salaries.

Alfred Johnson asked for a better hearing for the commercial engineer. He is a specialist in his line. In going from plant to plant he picks up the best ideas from each and where properly received is always ready to impart useful information. Mr. Parker, of Elgin, said that closer relations between the engineer and the salesman would result in mutual benefits. Men full of enthusiasm are needed in the various locals, and with them the membership could be greatly increased.

The Sessions of Thursday and Friday

Thursday morning's session was devoted mostly to routine business. The legislative committee reported that a new license bill had been prepared, had passed the House and had been brought up once in the Senate, but had been deferred for the time being. Reasons for the veto of the previous bill by the governor had been taken into consideration, and it was felt that the present bill would pass.

A report of the state deputy, W. E. Harris, showed a loss of 8 per cent. in membership. There are 18 cities in the state in which the organization is not represented. In these cities there are over 600 engineers, so that there is a fine opportunity to establish locals and boost the membership. The deputy offered a resolution which was passed later, suggesting that the state association follow the national body in presenting flags to the two locals in the state making the largest net gain in membership, based on percentage, during the year.

Thursday afternoon those interested visited the plant of the McLaughlin Coal Reduction Co., makers of atomized coal and the equipment to burn it for household and powerplant use. Thursday evening was devoted to social entertainment under the auspices of the exhibitors. There were dancing and refreshments, and to lend variety, two interesting talks, one by W. J. Nealey on "Benefits of Education to the Engineer," and the other by A. W. Cash on "Reducing and Regulating Valves."

A visit to the Staley starch works was made Friday morning, and the afternoon was devoted to the last business session of the convention. It was voted to pay part of the expenses of the delegates to the state convention. For next year the sum of $300 was appropriated for this purpose, the rate per mile to be decided later. Peoria was chosen as the next convention city and the following officers were elected: President, V. J. Bastian, No. 28, of Chicago; vice president, R. J. Mahood, No. 6, of Peoria; secretary-treasurer, W. E. Hill, No. 17, of Moline; state deputy, W. E. Harris, No. 1, of Chicago.

The exhibits were good and more numerous than usual.

Correction

In the article published on page 809 of the May 27 issue of *Power*, describing the superheater manufactured by the Locomotive Superheater Co., the address was given as Woolworth Building, New York City. This should have been 30 Church St., New York City.

Production of Electric Power for February, 1919

This Geological Survey report, prepared by W. B. Heroy, is based on returns received from 3150 electric power plants engaged in public service, including central stations, electric railways and certain other plants, the output of which contributes to the public supply. The returns received represent about 85 per cent. of the total generating capacity. For plants that did not make returns or that were unable to furnish the data requested, estimates of output were made from available information. The output for the month averages 110,000,000 kw.-hr. per day, of which 39 per cent. was produced by water power.

THOUSANDS OF KILOWATT-HOURS PRODUCED

State	By Water Power	By Fuels
Alabama	39,372	12,939
Arizona	3,967	16,395
Arkansas	77	6,275
California	190,462	38,295
Colorado	13,161	17,271
Connecticut	12,419	38,643
Delaware	0	5,549
District of Columbia	0	18,094
Florida	678	11,257
Georgia	35,497	7,236
Idaho	42,050	259
Illinois	13,701	241,930
Indiana	3,761	56,151
Iowa	44,214	23,110
Kansas	1,267	29,203
Kentucky	4	18,900
Louisiana	0	14,034
Maine	16,611	132
Maryland	278	18,448
Massachusetts	19,147	102,844
Michigan	49,980	97,187
Minnesota	24,525	28,708
Mississippi	0	5,789
Missouri	4,297	37,212
Montana	69,220	1,552
Nebraska	810	16,022
Nevada	2,913	137
New Hampshire	4,660	2,188
New Jersey	165	79,153
New Mexico	59	1,272
New York	204,590	288,986
North Carolina	43,234	2,820
North Dakota	0	2,308
Ohio	2,309	181,766
Oklahoma	223	12,092
Oregon	27,034	3,259
Pennsylvania	55,066	243,098
Rhode Island	383	28,767
South Carolina	64,745	3,235
South Dakota	4,624	3,751
Tennessee	43,780	8,368
Texas	165	43,151
Utah	48,906	0
Vermont	13,777	209
Virginia	14,693	17,685
Washington	71,160	5,667
West Virginia	1,453	51,584
Wisconsin	28,284	32,709
Wyoming	251	3,542
Total	1,220,972	1,879,182
Combined total	......	3,100,154

When the armistice was signed, the War Department had fifteen million regulation hand grenades ready to be thrown into the German trenches, dugouts and machine gun nests. As they were no longer needed for that purpose, the Treasury Department secured them for ammunition in the campaign for national financial preparedness. They will be used to clean out the entrenchments of the national enemies of waste and careless spending and will be handled by the army of American schoolchildren. Each grenade complete, except for the fuse and explosive charge, will be turned into a savings bank for dimes and pennies. Under a distribution plan approved by the Treasury Department one of these banks would be given to every schoolboy and schoolgirl under ten years old who can show one War Savings Stamp earned during vacation, when school reopens next fall and tell how it was earned. Every boy and girl over ten who earns two War Savings Stamps and who shows them together with an account of how they were earned, would win one of these prizes. The distribution of the grenade banks will be under the control of the Savings Directors of the twelve Federal Reserve Districts.

Charles M. Schwab, in an address before the Pan American Commercial Conference at Washington, D. C., spoke of the extensive plans he has made for the development of the steel industry in Chile. Mr. Schwab says that we must depend upon our friends in the South for the raw materials to make the East the successful steel-manufacturing center of the United States. He has recently opened in Chile on the west coast of South America the largest docks and shipping facilities in South America and has now under construction and under way, just started, twenty of the largest cargo ships that have ever been built, to carry twenty thousand tons of iron ore in each cargo, to ply between the west coast of South America and the Eastern ports of the United States.

Personals

Charles G. Sherman, formerly manager of the Atlanta (Ga.) branch of the Main Belting Co., is now connected with the Imperial Belting Co., Chicago, Ill.

L. L. Gerstenberger, formerly sales manager of the Main Belting Co. at Philadelphia, has been made assistant general sales manager of the Imperial Belting Co., Chicago, Ill.

Frank Duemler, of Badenhausen Co., has been transferred from the office of chief power-plant engineer at Cornwells Shops, to a position in the service and sales department of the company.

Fred B. Grosse has been released from service in the army and is back at his regular job as advertising manager of the Plant Engineering and Equipment Co. at its new offices, 192 Broadway, New York City.

H. L. Garbutt, for the last six years manager of the line material section of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, has been appointed manager of the supply division of the San Francisco office.

J. W. McCabe, who until recently was district manager of sales for the Chicago Pneumatic Tool Co., at Buffalo, has been appointed special representative for the company's foreign trade department and will depart shortly for an extended trip throughout the Orient, Philippine Islands and Australia. W. H. White has been appointed acting district manager of sales at Buffalo to take charge of that territory during Mr. McCabe's absence.

E. A. Hitchcock has recently become connected with the Bailey Meter Co., of Cleveland, Ohio, as vice president. He will supervise the training of technical graduates for the company's service and sales departments. During the last six years he has been connected with the E. W. Clark & Co. Management Corp. as advisory, consulting and power sales engineer. Previous to that time he was professor of experimental engineering at Ohio State University.

W. G. Balph has been appointed manager of the safety switch section of the Westinghouse Krantz factory, Brooklyn, N. Y. As head of this section Mr. Balph will have entire responsibility for the sale of all Krantz products, and in addition will have charge of the extension and development of this line to meet the needs of the country for safety switches. Prior to working as salesman in the New York office, Mr. Balph was head of the fan motor division at East Pittsburgh, Penn.

Engineering Affairs

The Connecticut State Association of Stationary Engineers will hold a convention in Speedwell Hall, Waterbury, June 27-28. An entertainment and dance will be given on the evening of June 27.

Phoenix Association No. 24, N. A. S. E., New York City, will hold a Victory outing on Sunday, June 29, at American Park, College Point, L. I. This outing, the first the association has held in the last two years, promises to be the most enjoyable ever.

The Hartford Branch of the Connecticut Section of the American Society of Mechanical Engineers held its last meeting for the season in the lecture room of the Hartford Electric Light Co.'s building on Thursday evening, June 5. Hiram Percy Maxim, inventor of the Maxim silencer, lectured on "Sound," illustrated by a series of remarkable slides showing photographs of sound waves and how they could be reflected, refracted, etc. Demonstrations were given of the silencer upon small-caliber and high-powered arms. The lecture was followed by a smoker at which Jack Armour, of "Power," and George A. Orrok, consulting engineer, entertained. The following officers were elected for the ensuing year: H. P. Maxim, chairman; S. F. Jeter, vice chairman; W. C. Beekley, secretary-treasurer; C. S. Blake, F. E. Howard, M. D. Church, W. P. Eales and R. S. Brown, executive committee.

National Electric Light Association—R. H. Ballard, the president-elect, has approved a plan for the four vice presidents' active participation in the real work of the association, thereby decentralizing the burden of responsibility upon the president, whose residence is on the Pacific coast. President Ballard will specially devote himself to matters of a general executive character. Martin J. Insull, first vice president, will be executive vice president and will preside over all meetings of the executive committee in case of the president's absence. M. R. Bump, second vice president, will supervise the work of the technical and hydro-electric section. Frank W. Smith, third vice president, will supervise the accounting section and work at association headquarters. W. H. Johnson, fourth vice president, will supervise the activities of the commercial and electric-vehicle sections and work on the enlargement and development of company sections.

Miscellaneous News

The Virginia State Corporation Commission has refused to grant the Northern Virginia Power Co. permission to increase its rates for electric lighting and power purposes in Virginia. This means that the company will have to continue supplying its customers there with electricity at the rates that have been in force for some time past, and that all contracts for lighting and power will remain in force as at present.

The Fourth Annual Summer School Course in Industrial Management will be given at the Pennsylvania State College, State College, Penn., Aug. 11-23. Major Hugo Diemer, formerly professor of industrial engineering at the college and now superintendent of personnel with the Winchester Repeating Arms Co., will conduct the course. Registration day will be on Aug. 9, at which time a fee of $25 is payable for the two weeks' session.

The New Greenbrier Power Plant of the Virginian-Western Power Co. at Ronceverte is practically finished and will shortly be placed in service. The capacity of the new plant is approximately 4000 hp. The building is of sufficient size to accommodate practically double its present capacity. The station will double the capacity of the Virginian-Western Power Co. system. The plant was designed by the J. G. White Engineering Corp. of New York, and constructed by them. The work was carried on in the name of the Greenbrier Power Co., which company is owned and controlled by the Virginia-Western Power Co., of Clifton Forge.

Business Items

The Barney Ventilating Fan Works (Albert B. Franklin, Inc.) has moved its offices and factory to 25-27 Haverhill St., Boston, Mass.

The Adapti Co., of Cleveland, has changed the location of its Chicago branch office to 210 Madison Terminal Building, corner of South Clinton and Madison Avenues, with J. H. Dutton in charge.

The Ohio Brass Co., Mansfield, Ohio, announces that A. J. Kehoe is now salesman in the central territory, and P. A. Green has been appointed assistant sales agent in the home office.

The Betson Plastic Fire Brick Co., Inc., was recently organized at Rome, N. Y., with Frank J. Jewell, of the firm of Adams & Jewell, as president and secretary, and Nelson Adams vice-president and treasurer.

Plant Engineering and Equipment Co., Inc., has opened a branch office in the Cox Building, Atlanta, Ga., to take care of business in the states of South Carolina, Georgia and Florida, with John A. Culver as manager.

The Poole Engineering & Machine Co. has moved its general sales office from Baltimore, Md., to 50 Church St., New York City. W. C. Tyler, formerly district manager at New York, has been appointed general sales manager in charge of all company sales.

Wm. B. Scaife & Sons Co., of Pittsburgh, announces the opening on July 1, of a Chicago sales and engineering office at 38 South Dearborn St., with Charles F. O'Hagan, formerly chief engineer of the company at Pittsburgh, as resident engineer and manager.

The Homestead (Penn.) Valve Manufacturing Co.'s Midwestern sales representatives held a regional convention at the Sherman Hotel, Chicago, May 30-31. Addresses bearing on the company's policies and products and along general advertising sales lines were made by various speakers.

The Buffalo Forge Co. announces that Lieut. C. C. Cheyney, who has had charge of the mechanical repair shops at the Naval Aviation Station, Pensacola, Fla., has been released from the service and has returned to take charge of its Chicago office and store. Captain H. H. Downes, upon receiving his discharge from the army, will take charge of the company's interests in the St. Louis territory.

Ophuls, Hill & McCreery, Inc., have been retained as architects and engineers in the design and construction of a fish-freezing plant for the French government on the Isle of St. Pierre, off the coast of Newfoundland. This will be the largest fish-freezing plant on the Atlantic coast. The building will be of concrete. The contract has been let to the Turner Construction Co. Specifications for the mechanical, electrical and refrigerating apparatus are being prepared and will be issued June 21. The whole proposition is to cost between $600,000 and $700,000.

Trade Catalogs

Sprague Electric Dynamometers. Sprague Electric Works of General Electric Co., New York City. Bulletin No. 48701-A, superseding Bulletin No. 48701.

The Massachusetts Blower Co., Watertown, Mass., has issued Bulletin 51, which presents in a condensed form the more general data on the company's products. A copy may be had free upon request.

The Combustion Engineering Corp., New York City, has just issued a new folder describing an improvement in the dumping arrangement of the Type "E" stoker which makes for greater efficiency and labor saving in the boiler room.

The Jas. A. Brady Foundry Co., of Chicago, has issued the fourth edition of the Brady Steam Jet Ash Conveyor bulletin. This 36-page catalog illustrates and describes the conveyor in detail and shows a number of recent installations.

The Defender Automatic Regulator Co., St. Louis, Mo., has just published a new general catalog No. 11, illustrating and describing the largest assortment of combustion appliances and boiler room economy instruments offered by any one house.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8.05@8 35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2 15@2 75	$2 75@3 25
Philadelphia, gross tons	4 27@4 95	5 95@5.50
New York, gross tons	4 62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7.90	Pea	4 90	6 65
Egg	5 95	7.80	Buckwheat	3 40	5 15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2 25	4 00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2 95 @ $3 50
Cambria County (good grades)	2 75 @ 2 95	2.95 @ 3 25
Clearfield County	2.50 @ 2 75	2.80 @ 2.95
Reynoldsville	2.50 @ 2 75	2.75 @ 2.95
Quemahoning	2.65 @ 2 85	2.95 @ 3.10
Somerset County (best grades)	2.50 @ 2 75	2 95 @ 3 10
Somerset County (poorer grades)	2.00 @ 2 35	2.50 @ 2 75
Western Maryland	2.25 @ 2 50	2.50 @ 2.75
Fairmont	2.00 @ 2 25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2 25 @ 2.40
Greensburg	2.25 @ 2.35	2 35 @ 2.60
Westmoreland	2.60 @ 2.75	2 60 @ 2.75
Westmoreland run-of-mine	2.35 @ 2.60	2 35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6.05	7.90	Rice	2.75	3.65
Stove	6 30	8 15	Boiler	2 50	3 50
Nut	6 40	8 25	Barley	2 25	3 15
Pea	5 00	6.60	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3 45	3 75	3 05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.95@$4.60
Corona	3.50
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2 00@2.25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	...
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; other rates 92½c.

New Construction

PROPOSED WORK

N. Y., Brooklyn—The Pirika Chocolate Co., Inc., 972 Dean St., will install a steam heating plant in the 3 story, 78 x 120 ft. factory which it plans to build on Dean St. and Carlton Ave. Total estimated cost, $125,000. Timmis & Chapman, 315 5th Ave., New York City, Engr.

N. Y., Canton—The Board of Education will receive bids for the installation of a heating and ventilating system in school. Estimated cost, $15,000. Address the Supt.

N. Y., Middletown—The State Hospital Commission, Capitol, Albany, will receive bids until July 1 to install a heating plant in the new building which it plans to build for chronic patients, at the Middletown State Homeopathic Hospital. L. F. Pilcher, Albany, State Arch.

N. Y., New York—H. S. Coffin, 44 Pine St., will install a steam heating plant in the 2 story, 99 x 188 ft. garage which it plans to build at 388-394 11th Ave. Total estimated cost, $100,000. G. M. McCabe, 96 5th Ave., Engr.

N. Y., Ossining—C. F. Rattigan, Supt. of State Prisons, Hall of Records Bldg., Centre and Chambers St., New York City, will receive bids until June 24 for the construction of a 25 x 27 ft. pump house and a heating plant, also the installation of two 400 hp. boilers in the power house at the Sing Sing prison here. L. F. Pilcher, Capitol, Albany, State Arch. Noted May 27.

N. Y., Utica—Horrocks-Ibbotson Co., 54 Genessee St., has had plans prepared by W. L. Strobel, Arch., Martin Bldg., for the construction of a factory and office building on Whitesboro St. A heating system and electric power equipment will be installed in same. Total estimated cost, $75,000.

N. J., Cape May—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build a pump house and install oil and gasoline piping and pumping system, etc., at the Section Base here. Specification No. 3721.

N. J., Newark—The Board of Education will soon award the contract for the construction of a power house in connection with the 4 story, 163 x 223 ft. vocational school which it plans to build on Sussex Ave. Total estimated cost, $500,000. J. H. & W. C. Ely, Firemans Bldg., Arch.

Penn., Johnston—H. J. Cartin, Secy. of Bd. of Directors of the Conemaugh Valley Memorial Hospital, will soon award the contract for the construction of a 2 story boiler house on Franklin St., 8th Ward. Estimated cost, $25,000. W. R. Myton, 1204 1st National Bank Bldg., Arch.

Penn., Reading—The Philadelphia & Reading R. R. Co., Reading Terminal, Philadelphia, will soon award the contract for the construction of a 1 story, 38 x 50 ft. power house here. A. E. Owen, Reading Terminal, Philadelphia, Engr.

Md., Baltimore—The Maryland Ice Cream Co., 1723 East Pratt St., has acquired a 4 story, 50 x 100 ft. building and plans to build an addition and convert same into a refrigerating plant.

D. C., Washington—A. Flint, General Purchasing Officer of the Panama Canal, will receive bids for furnishing condenser tubes and thimbles, motor generator sets, starting compensators, transformers, fans, reflectors, fuses, etc.

Ohio, Cleveland—The Berkshire Realty Co., 517 Sloane Bldg., will install a steam heating plant in the 11 story, 66 x 147 ft. mercantile building which it plans to build on East 6th St. G. A. Grieble, 517 Sloan Bldg., Arch.

Ohio, Cleveland—The Daisy Hill Co., Maschal Bldg., is in the market for a 100 to 150 hp. stationary boiler for greenhouse use.

Ohio, Cleveland—J. M. Halladay, 9414 Richmond Ave., will install a steam heating plant in the 2 story, 75 x 200 ft. factory which it plans to build. Total estimated cost, $150,000. Watson Engineering Co., 1101 Hippodrome Bldg., Engr.

Ohio, Cleveland—The Van Dorn Electric Tool Co., 2978 Woodhill Rd., will install a steam heating plant in the 4 story, 50 x 100 ft. factory which it plans to build. Total estimated cost, $100,000. W. J. Carter, 723 Illuminating Bldg., Engr.

Ohio, Minerva—The Board of Public Affairs plans to install new electric light equipment, dynamos, engines, boilers and electric pumps to enlarge the capacity of the existing plant.

Mich., Detroit—The General Motors Corp., Boyer Campbell Bldg., plans to build a 1 story 100 x 360 ft. heat treating shop on Holbrook and St. Aubin Ave. Esselstyn, Murphy & Hanford, 510 Marquette Bldg., Engr.

Mich., Ecorse—The village plans to install an auxiliary pump to be used as a booster pump, in connection with building a 500,000 gal. reservoir, and extending the water mains. R. A. Murdok, Engr.

Ill., Chicago—The Board of Education, 5 South Dearborn St., will install a steam heating plant in the 3 story, 169 x 263 ft. school which it plans to build on West 18th St. and South Keeler Ave. Total estimated cost, $650,000. J. Howatt, c/o the Bd. of Education, Engr.

Ill., Chicago—The Chicago Title & Trust Co., 69 West Washington St., will install a steam heating plant in the 6 story, 70 x 80 ft. mercantile building which it plans to build on Michigan and Lake St. Total estimated cost, $200,000. J. Hunt, 30 North Michigan Ave., Arch.

Ill., Chicago—The Gordon-Page Co., 461 Chene St., will install a steam heating plant in the bakery plant which it plans to build at 5324 Federal St. Total estimated cost, $125,000. A. Woltersdorf, 138 North La Salle St., Arch.

Ill., Chicago—R. A. Pottinger, 4005 Irving Park Blvd., has awarded the contract for the construction of a 4 story, 45 x 130 ft. hotel which it plans to build at 4128 Irving Park Bldg., to the Hecla Construction Co., 4601 North Monticello Ave. A steam heating plant will be installed in same. Total estimated cost, $100,000.

Ill., Chicago—G. Rasmussen Co., 615 West Randolph St., will install a steam heating plant in the 2 and 6 story warehouse which it plans to build on Oak and Kingsbury St. Total estimated cost, $400,000. J. B. Bohm & Son, 138 North La Salle St., Arch.

Ill., Chicago—The Ritz Hotel Co., c/o W. W. Ahlschlager, Arch., 111 West Washington St., will install a steam heating plant in the 10 story, 100 x 150 ft. residence hotel which it plans to build on Kenmore and Granville St. Total estimated cost, $1,000,000.

Ill., Chicago—W. Wrigley, Jr., Co., 5 North Wabash Ave., has awarded the contract for the construction of an 8 story, 80 x 343 ft. warehouse on Ashland Ave., near 36th St. to E. W. Sproul Co., 2001 West 39th St. A steam heating plant will be installed in same. Total estimated cost, $600,000.

Ill., Chicago Heights—The Chicago Heights Country Club will install a steam heating plant in the 6 story, 100 x 142 ft. clubhouse which it plans to build on Illinois and Oak St. Total estimated cost $300,000. P. Gerhardt, 64 West Randolph St., Chicago, Arch.

Ill., Columbia—The city plans election soon to vote on $16,000 bonds for extending and improving the electric light plant.

Ill., East Moline—The city plans election soon to vote on bonds for the construction of a new pumping station on 11th St. and 3rd Ave., to include the installation of 2 pumps for the pumping sewage. Estimated cost, $28,000.

Minn., Duluth—The Board of Education, Glencoe Building, will install a steam heating and mechanical ventilating system in the one story, 115 x 260 ft. school which it plans to build on Minnesota Ave. Total estimated cost, $100,000. Croft & Boerner, Lonsdale Bldg., Engr.

Minn., Harmony—T. S. Brokken, City Clk., will receive bids until June 19 for the construction of pump house and a 10 x 10 ft. compressed air water tank. Druar & Smith, 513-14 Globe Bldg., St. Paul, Engr.

Kan., Wichita—The Board of Education will install a steam heating plant in the 3 story school which it plans to build on 3rd and Hydraulic St. Total estimated cost, $160,000. J. L. Leland, Sec'y. L. Schmidt, 121 North Market St., Arch.

Neb., Omaha—E. L. Means, Orleans, will install a steam heating plant in the 6 story, 120 x 132 ft. wholesale grocery building which it plans to build on 11th and Dodge St. Total estimated cost, $150,000. J. Latenser & Sons, 632 Bee Bldg., Engr.

Mo., Joplin—Scottish Rites F. & A. M. will install steam heat, electric power, boilers, motors, etc., in the 2 story, 125 x 150 ft. cathedral which they plan to build on 5th Ave. Total estimated cost, $250,000. T. L. Brown, 603 North Pearl St., Secy.

Tex., Dallas—The Dallas Power & Light Co., Interurban Bldg., plans to build a sub-station. Estimated cost, $250,000.

Tex., Dallas—The Federal Reserve Bank, Commerce and Martin St., will install a steam heating plant in the 5 story, bank which it plans to build. Total estimated cost, $500,000. Graham, Anderson, Probst & White, 120 Broadway, New York City, Arch.

N. M., Silver City—The Black Hawk Mining & Milling Co. is in the market for general power, air and pumping equipment. E. D. Lidstone, P. O. Box 456, Silver City, Mgr.

Ariz., Winkleman—The Aztlan Manufacturing Co. is in the market for power equipment, in connection with the 100 ton mill which it plans to build. Total estimated cost, $150,000. H. Whitcomb, Mgr.

Ore., Roseburg—The Umpqua Valley Fruit Union plans to build a 4 story, 50 x 180 ft. packing house and cold storage plant. R. C. Wood, Mgr.

Cal., Avalon—The city plans an election soon to vote on $[illegible] bonds for the construction of a combined electric light and waterworks plant, on Catalina Island here.

Cal., Los Angeles—The Board of Public Service Commission, 645 South Olive St., will receive bids until June 27 for furnishing hydraulic equipment, electric generators, transformers, auxiliary electric equipment and appurtenances for power plant No. 2 in the San Francesquito Canyon, Northeast of Chatsworth P. O. Estimated cost, $[illegible]. E. F. Scattergood, Ch. Electrical Engr. Noted June 3.

Cal., Ventura—The Board of Supervisors of Ventura County is having plans prepared by A. C. Martin, Arch., 430 Higgins Bldg., Los Angeles, for the construction of a 2 story hospital, to include power house, etc. A steam heating system and boilers will be installed in same. Total estimated cost, from $150,000 to $200,000.

Que., Robeval—The Town Council is in the market for 1 horizontal shaft turbine, 300 hp., head 50 ft., speed 600 r.p.m.; one 250 k.v.a., alternate current generator; 1 exciter and 1 switchboard. T. F. Grenon, Chicoutimi, Engr.

Ont., Bridgeport—The School Board will install a modern heating and ventilating plant in the Phipps St. School. Estimated cost, from $10,000 to $12,000. J. D. Fitzgibbon, Engr.

Ont., Lakeside—The Town Council plans to extend the electric plant. J. W. Sutherland, Town Clk.

Ont., London—The Utilities Board, Hydro Offices, will receive bids about July 1 for the construction of a 1 story, 40 x 55 ft. hydro-substation at North London. Estimated cost, $15,000. E. V. Buchanan, Hydro Offices, London, Arch.

Ont., Watford—The citizens plan to vote on $55,000 by-law for the construction of a pump house, to include the installation of steam driven pumps, of 300 imperial gals.; standpipe, pumping equipment, etc. W. S. Fuller, Watford, Engr.

Alta., Vermilion—The Town Council has appropriated $16,000 for extending the electric plant.

CONTRACTS AWARDED

R. I., Providence—The Atlantic Mills, Equitable Bldg., Boston, Mass., has awarded the contract for the construction of a 3 story, 46 x 98 ft. power house on Manton Ave., to O. D. Purington & Co., Industrial Trust Bldg. Estimated cost, $25,000.

N. Y., Wards Island—L. F. Pilcher, State Arch., has awarded the contract for installing laundry machinery and motors at the Manhattan State Hospital, to J. Livingston & Co., Inc., Grand Central Terminal, New York City. Estimated cost, $11,950.

Ont., Leamington—The Imperial Tobacco Co. has awarded the contract for the construction of a 1 story, 35 x 75 ft. power house and 125 x 250 ft. factory on Eris St., to Archibald & Holmes, Excelsior Life Bldg., Toronto. Estimated cost, $80,000.

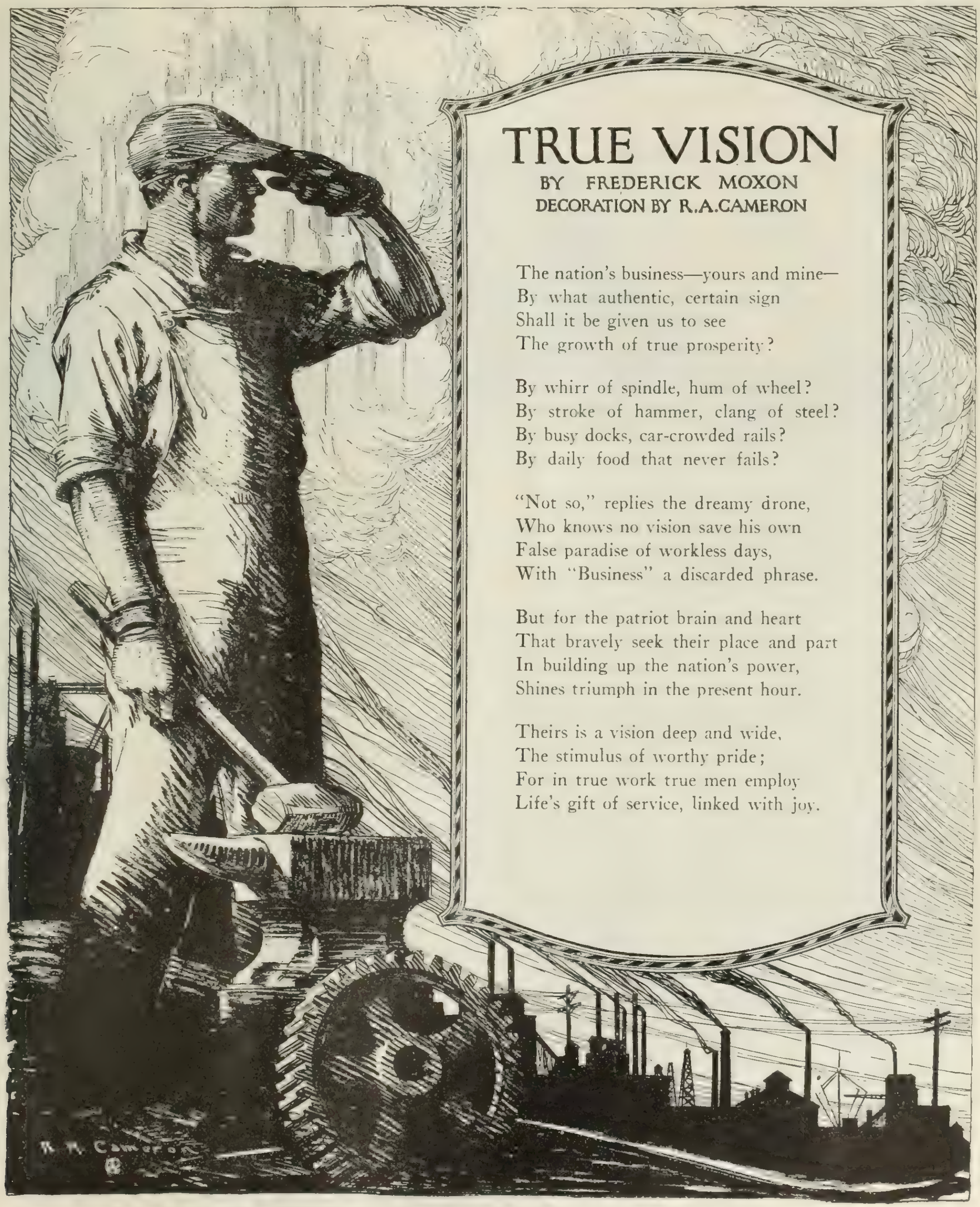
"Opportunity" Advertising

Think "SEARCHLIGHT" First!

SEE PAGES 74 TO 88B

POWER

Volume 49 New York, June 24, 1919 *Number* 25



TRUE VISION

BY FREDERICK MOXON

DECORATION BY R. A. CAMERON

The nation's business—yours and mine—
By what authentic, certain sign
Shall it be given us to see
The growth of true prosperity?

By whirr of spindle, hum of wheel?
By stroke of hammer, clang of steel?
By busy docks, car-crowded rails?
By daily food that never fails?

"Not so," replies the dreamy drone,
Who knows no vision save his own
False paradise of workless days,
With "Business" a discarded phrase.

But for the patriot brain and heart
That bravely seek their place and part
In building up the nation's power,
Shines triumph in the present hour.

Theirs is a vision deep and wide,
The stimulus of worthy pride;
For in true work true men employ
Life's gift of service, linked with joy.

U.S. Nitrate Plant No.1

By
Edward R. Welles
and C. T. Mitchell

POWER STATION FOR U. S. NITRATE PLANT NO. 1 AT SHEFFIELD, ALA.

A modern plant of 5000 kw. capacity in turbogenerators and eight water-tube boilers of 5016 sq.ft. heating surface each, operating at 200 lb. pressure and 125 deg. F. The three main turbines are of the bleeder type for furnishing process steam for the process of nitrogen fixation.

A 5000-kw. steam power plant forms part of the equipment of the nitrogen fixation plant built for the War Department at Sheffield, Alabama, for the production of ammonium nitrate by The J. G. White Engineering Corporation. This power plant is not directly comparable to the average lighting or power station since a considerable proportion of the total steam produced is used directly in the process.

The building itself is 165 x 77 ft., one end of this rectangle being occupied by the boilers, the other end by the turbines and electrical equipment. Space in addition to the above area is occupied by two radial brick stacks, a cooling pond, an adjacent water-softening plant and a small extension to the main building to accommodate two air compressors. Another small extension on the boiler-room end forms the coal-elevator shaft and also houses a stairway leading to the top of the building. In external design the building conforms with the other principal buildings of the plant, the walls being of red brick with limestone belt course, window trim and cornice. Ample window space has been provided, with the result that the boiler room is as cool in warm weather as any other part of the building.

Coal, on being received, is either unloaded in the storage yard by a locomotive crane or dumped directly into the coal pocket at the boiler room. The pocket consists of a steel hopper 10 x 12 ft. in plan with a reciprocating feed at the bottom delivering to two crushers with rolls 28 in. diameter by 30 in. long. Each crusher delivers to a bucket elevator having 20 x 20-in. buckets spaced 36 in. apart. These elevators become conveyors at the top of the bunker over the boilers and distribute the coal, with a capacity of 100 tons each per hour. The bunker is of the straight-sided hopper bottom type, built of concrete in structural steel framing and holding 500 tons of coal. Ten gates, 16 x 16 in. square deliver the coal to a weighing larry operated by two ropes from the boiler-room floor. This larry is moved from gate to gate with the assistance of a 2-hp. motor, as needed, interlocking with the gate and releasing a catch which otherwise prevents the gate from opening. Before passing to the stoker the coal is weighed in the larry by the attendant, the weight being recorded.

The boiler-room equipment consists of 8 Stirling boilers rated at 502 hp. each, built with brick settings in four batteries facing each other across an 18-ft. aisle space. High-temperature cement was used in the settings in place of fireclay wherever the brick is exposed directly to the fire. Each boiler is designed for a working pressure of 200 lb. and has a heating surface of 5016 sq.ft., making the total heating surface 40,128 sq.ft. The high ratio between the boiler heating surface and kilowatts generated is explained by the fact that a large proportion of the steam is used in the chemical process as already noted. Each boiler is equipped with soot blower and superheater, the normal superheat being 125 deg. Soot, after being blown from the tubes, is collected in a hopper back of the mud drum and passed through a chute to the ash cars below. A CO_2 recorder on each boiler keeps the fireman constantly informed as to the status of combustion. Each row of boilers is served by a separate smoke flue and stack, the flue being rectangular in section mounted directly behind the boilers, with hollow tile floor and roof and 8-in. brick walls plastered inside with cement. The usual steel breeching connects each flue with the stack. The stacks are 10 ft. inside diameter at the top and 200 ft. high above the base, or 182 ft. high above the boiler-room floor.

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*Mechanical Division, J. G. White Engineering Corporation

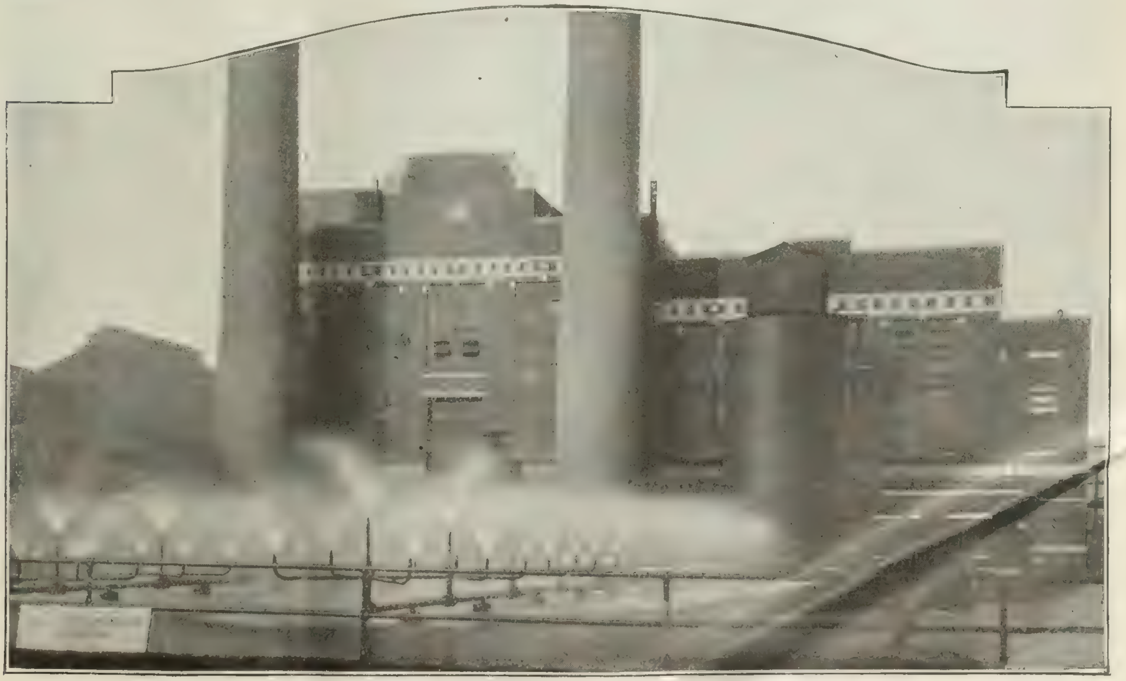
A five-retort underfeed stoker serves each boiler. The eight stokers are operated by four vertical cylinder engines placed directly on the boiler-room floor, where they are easily accessible. Each engine has sufficient capacity to operate four stokers. Shafting running under the floor transmits the motion from the engine to the retorts by means of chain drives. Air is supplied to the stokers through a rectangular steel duct from four conoidal multiblade stoker fans mounted in the basement below the boilers. These fans are direct connected by flexible couplings to four steam turbines and operate normally at 2090 r.p.m. The stoker feed is controlled by means of a device operating directly on the throttle of the stoker engines, and actuated by the pressure in the windbox. The windbox pressure is again automatically controlled through a regulating valve by the steam pressure. A hand-operated reversible ratchet and worm-wheel device serves to dump the ash into concrete-lined ash hoppers below, from whence it is removed in hand-pushed side-dump cars, and distributed over the low ground surrounding the plant.

The capacity of the stokers is sufficient to operate the boilers at 200 per cent. of their normal rating, though it was not anticipated that such a high rating would have to be maintained except in rare emergencies. Since the power load and the demand for process steam would remain very constant, it was deemed advisable to have sufficient boiler capacity to be able to operate at between 125 per cent. and 150 per cent. of rating, which is the point of highest economy.

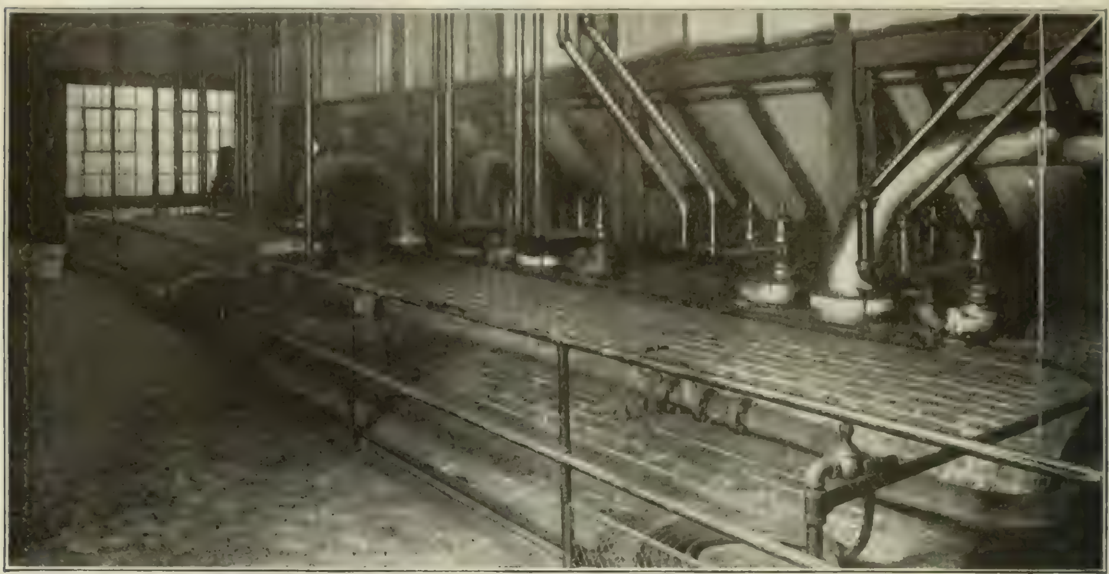
Three four-stage centrifugal boiler-feed pumps supply the water to the boilers, each pump being direct connected to a single-stage steam turbine. Any two pumps are amply large to supply the total amount of feed water, the piping being so arranged that any pump may serve any boiler or group of boilers. Venturi meters are installed on the feed line with recording integrating attachments to measure the flow. Each boiler is equipped with a thermostatic expansion-tube type of feed-water regulator, which in conjunction with pump governors affords complete automatic control of the feed-water supply.

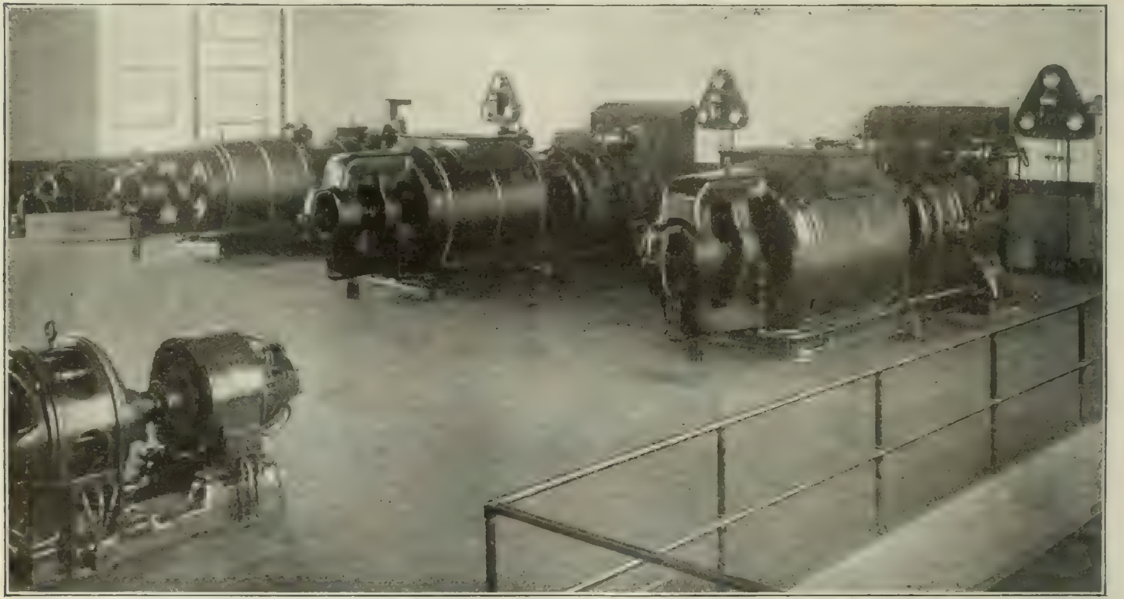
The feed pumps receive their water from an open-type feed-water heater having lime-catching and heating surface of about 1000 sq.ft. This heater is located high enough to afford a head of about ten feet on the suction side of the feed pumps. It receives the exhaust steam from the stoker engines, vacuum pumps, circulating pumps, and from two air compressors. By means of a thermostatic valve operating a bypass from a ten-pound exhaust line leading to the process, the required temperature in the heater is maintained constant. The heater may receive its water from any one of three sources: Directly from the water main; from the cooling pond through the circulating pump line; or, normally, through the water softener. All sources of water lead back eventually to the pumping station at Spring Creek, a tributary of the Tennessee River. During periods of settled weather the water is received from there in a state of sufficient clarity for boiler-feed and cooling-water purposes. A large gravity filtering plant removes all sediment from the water in times of stormy weather before delivering it to the plant.

As the water contains a certain amount of lime and



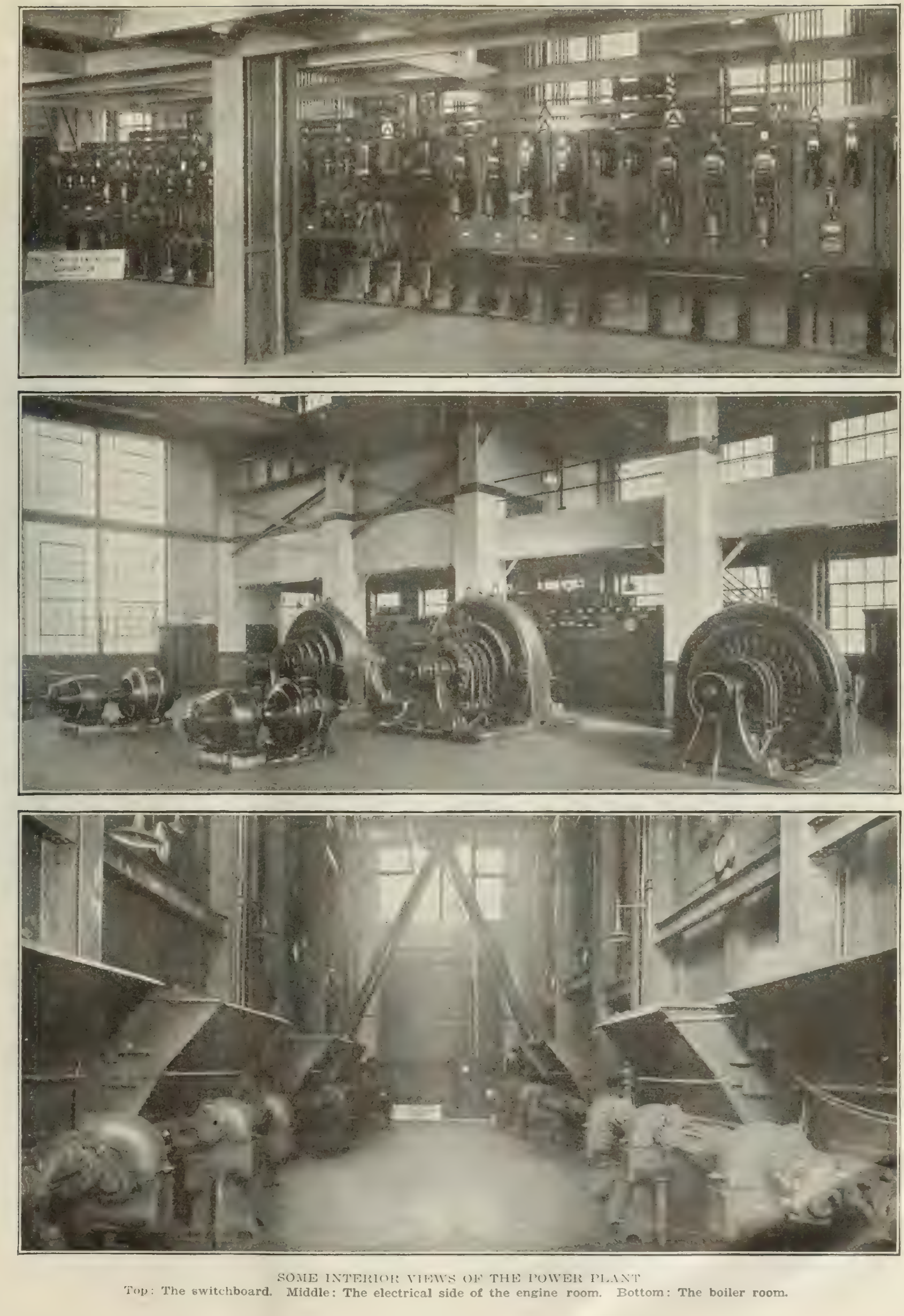
SHOWING THE SPRAY COOLING POND IN BACK OF THE STATION other scale forming material, a water-softening plant was installed adjacent to the power house, consisting of a steel settling tank 21 ft. in diameter by 42 ft. 6 in. high, together with mixing and stirring devices and quartz sand filter. Water is received from the ammonia-process building where it has been warmed in passing through apparatus to from 100 to 120 deg. These few degrees above the average temperature of about 70 deg. offer a certain assistance to the softening process and represent a slight thermal credit in the heat balance. This water is forced to the top of the softener by one of two centrifugal pumps direct connected to a 15-hp. motor. Here it is automatically mixed with the proper amount of softening material and delivered to the settling tank, where it remains about six hours, then passes by gravity through a sand filter directly to the feed-water heater. A float valve on the settling tank controls the admission of water to the softener, in accordance with the demand of the heater. Complete flexibility of piping is arranged for so that the softener may be bypassed, or water either from the main or the cooling pond may be passed through it as well as the water from the process. A venturi meter records the flow through the softener.





TOP: AN UNUSUALLY CLEAN AND ROOMY SPACE ABOVE THE BOILER TOPS. BOTTOM: THE STEAM SIDE OF THE ENGINE ROOM

The generating part of the plant is embodied in three bleeder turbines, one of 1250 kv.-a., and two 1875 kv.-a. capacity. The reason for this divergence in size is that the smaller unit had already been purchased by the General Chemical Co. to be used in a nitrogen fixation plant of their own before the Government adopted their



SOME INTERIOR VIEWS OF THE POWER PLANT
Top: The switchboard. Middle: The electrical side of the engine room. Bottom: The boiler room.

process and took over whatever equipment had been ordered, with the intention of using it in the larger plant now in operation. These turbines are interesting in that they possess a large diaphragm valve operating in the main body of the shell which automatically releases sufficient steam at the 10-lb. pressure stage to maintain 10 lb. in a line running to the process part of the plant. The main body of the steam in this line consists of the exhaust from two low-pressure air compressors, the boiler-feed pumps, the forced-draft fans and the exciter (when running). The turbines supply from 10 per cent. to 30 per cent. of the steam, according to the number of units of the process in operation. They also act as a pressure regulator in the exhaust line, this being the most important function of the bleeding operation. The generators operate at 3600 r.p.m. and deliver at 190 volts 60 cycle six-phase. As direct current is chiefly used in the plant, most of the current generated is converted in three rotaries located opposite the turbines on the turbine-room floor. An air washer in the basement with a capacity of 21,600 cu.ft. per minute cleans all the air that passes through the turbines; a batch-type oil filter, also in the basement, receives the oil from any one unit when shut down, filters the oil and returns it by means of a small plunger pump.

LOW-HEAD JET CONDENSERS

The condensers, located directly beneath the turbines, are of the low-head jet type. They receive their condensing water from a concrete trench connecting directly with the cooling pond. Each condenser is protected by a 14-in. atmospheric relief valve. A 12-in. circulating pump removes the water from each condenser and delivers it to the sprays against a total head of not over 35 ft. Each pump is direct-connected to a steam turbine, operates at 2600 r.p.m. and delivers 1730 gal. per minute. The shafts of the pumps are extended to admit of possible future motor connection. Three 8 x 20 x 12-in. horizontal single-stage rotative dry vacuum pumps complete the condenser equipment. The fact that a considerable proportion of the total steam is used in the process and is not recoverable, had a determining influence on the choice of type of condenser. Each condenser is equipped with a recording thermometer.

A 24-in. cast-iron pipe conveys the water from the circulating pumps to the spray pond, a distance of about 90 ft. The pond itself is constructed of waterproofed concrete 167 ft. long by 100 ft. wide. Three lines of 10-in. asphalt protected pipe are supported over the surface, each line carrying fifty spray nozzles.

Four air compressors are housed in the power plant building, though not strictly a part of the equipment. Two of these machines are horizontal cross compound two-stage, delivering air at 100 lb. pressure at a displacement capacity of 632 cu.ft. per minute each. The air from these machines is used in the machine shop and ammonia-process building, also for operating boiler-tube cleaners, blowing out electrical apparatus, and assisting in the daily cleansing of the filter in the water softener. The exhaust from the steam cylinders is directed to the feed-water heater. The other two machines are tandem Corliss compound, compressing single-stage in the air cylinders and delivering air at 35 lb. gage pressure with a displacement capacity of 1395 cu.ft. each. This air is used entirely in the process. The exhaust steam from these machines is also delivered to the process on the 10-lb. pressure line previously referred to.

Steam flow meters are installed as follows: on each turbine lead, on the line to the low-pressure compressors, and on a 6-in. high-pressure line to the process.

All high-pressure piping over 3½ in. in diameter in the power plant is made up with Van Stone ends and rolled steel flanges. All low pressure pipe over 12 in. in diameter is likewise made up with Van Stone flanges. All high-pressure steam valves are cast steel with monel-metal stems, seats and disks. Magnesia was used for all pipe insulation. All equipment throughout the plant is of the most modern, approved type.

[Considerable refrigeration capacity is required for the chemical processes in the nitrate-manufacturing buildings.—Editor.]

IMPORTANT DATA ON POWER PLANT OF THE UNITED STATES NITRATE PLANT NO. 1 AT SHEFFIELD, ALA.

BOILER ROOM

Dimension boiler room	75 ft. long by 80 ft. wide
Width firing aisle, ft.	18
No. of boilers	eight, 502 hp. each
Type of boilers	Stirling—0-23
Steam drums, three	42 in. dia. x 12 ft. 10¼ in. long, ⅞-in. plate
Mud drum	48 in. x 11 ft. 7¾ in. long, ⅝-in. plate
Tubes	380, 3¼ in. diameter
Heating surface, sq.ft., each boiler	5,016
Grate surface (active) sq.ft. per boiler	94.75
Heating surface per sq.ft. active grate area	53
Heating surface per installed kilowatt, normal capacity of generators	8
Pressure, lb. per sq.in.	190
Superheat, deg. F.	125
Total steam temperature, deg. F.	509

Coal analysis upon which stoker performance is based, per cent.:

Fixed Carbon	Volatile	Moisture	Ash	Sulphur	B.t.u. per Lb.
70	22	1	7	1	14,200

Boiler settings, floor plan dimensions	25 ft. 0 in. x 21 ft. 1¾ in. (no arches)
Stokers, type, Westinghouse underfeed	5 retorts per boiler

Stoker drive—Chain drive from vertical engines

Stoker performance: 76 per cent. combined boiler and furnace efficiency at 100 per cent. rating

Forced-draft fans: Four Buffalo Forge No. 4½ Turbo conoidal type, direct-connected to Terry turbines, 2090 r.p.m., 51 b.h.p. each.

Coal handling: Railway cars dump into hopper service by bucket elevator to bunkers. Locomotive crane in yard.

Bunkers	Steel frame, concrete
Capacity of bunker	500 tons
Coal to Stokers	One weighing larry serves all boilers
Soot blowers	Diamond type
Main steam valves	Walworth type
Automatic stop valves	New Bedford type
Blowoff valves	B. L. W. type
Size of steam header	8 in.

Feed-water heater: One Hoppes type, horizontal, capacity 6,000 hp.

Heater capacity per rated horsepower capacity of boilers installed, boiler hp. 1.5.

Feed pumps, three, Alberger type.

Type, centrifugal 3 lb., four-stage, 200 gal. per min. at 2700 r.p.m. driven by Alberger-Curtis steam turbines.

Water softener, American, steel tank, tipper type, 25,000 gal. per hr. capacity

Chimneys: Alphonse Custodis radial brick: Type 10-ft. top diam. by 182-ft. high above boiler room floor.

Coal burned per sq.ft., minimum cross sectional area at 100 per cent. boiler rating, lb. per hr. (based on four boilers per stack)....282

CO_2 Recorders: Uehling type, two machines recording gas from eight boilers

TURBINE ROOM

Three turbines, General Electric, one 1250 kv.-a., two 1875 kv.-a., Curtis, bleeder type, 60 cycle, six phase, 190 volts

Steam which may be extracted from 1875 kv.-a. unit at 10 lb. gage for varying loads.

Load, Kw.	Lb. Steam Extracted	Flow of Steam to Condenser, Lb.
1875	24,000	19,900
1875	5,000	28,500
1405	38,000	5,850
1405	5,000	20,750
937	23,200	1,700
937	5,000	14,000

Speed	3,600 r.p.m.
Excitation	35 kw. 125 volts
Ventilation	One air washer, capacity 21,600 cu.ft. per min.
Oil-filtering system	Richardson-Phenix
Capacity	24 gal. per hr., batch type
Three synchronous converters	General Electric type
Capacity	Two at 1700 kw., one at 1150 kw. 514 r.p.m.

CONDENSERS

Type	Low head, jet, Alberger type
Exhaust connection	Diameter, 1250 kv.-a. turbine, in. 30
Exhaust connection	Diameter 1875 kv.-a. turbine, in., 36
Removal pumps, centrifugal	Alberger type
Capacity, for 1250 kv.-a. unit	1730 gal. per min.
Cpacity, for 1875 kv.-a. unit	2600 gal. per min.
Drive	Alberger-Curtis turbine with reducing gear
Pounds of condensing water to pounds of steam:	
Condensed, maximum conditions	43
Vacum pumps	8x20x12 in. horizontal, single-stage, rotative dry vacuum type
Spray pond, capacity	6000 gal. cooling water per min.
Size 167 ft. x 100 ft	150 nozzles

Improving Operation in Typical Industrial Plant Boiler Room

By J. T. Beard, Jr.*

Driven to desperation because of shutdowns brought about by poor coal a manager decides to improve conditions in the boiler room. It is a typical plant where the usual causes of deplorable inefficiency have long existed, where the management refused the draft gages, scales and instruments so many times asked for by the engineer, and where collapse of operation was necessary before real measures of relief would be permitted. There is many an engineer who might with good effect hand the article to his management.

THE plant discussed in this article was confronted with problems of car shortage and "fireless coal," which sometimes ran as high as 60 to 80 per cent. ash. The fireman could not hold his steam and the plant had to shut down frequently. For the first time the manager realized that he had a boiler room and that it was an essential part of the plant. The effect of this sudden awakening was that the manager got a little madder, cussed and discussed the coal man, the Fuel Administration, and generally made life a little harder for the men around the plant. He did not see any connection between his predicament and those draft gages, coal scales and instruments which the chief engineer had asked for back in 1908.

Manager Realizes the Importance of Boiler Room

The situation at the plant got worse. Frequent shutdowns were not unusual, and the decreased production began to tell on the profit side of the sheet. He realized at last the vital importance of the boiler room and its continuous operation, and he decided that he must "right-about-face." He went further. He retained the services of a firm of engineers, expert in this line of work, to coöperate with his chief engineer and to assist and advise in the economical operation of the boiler room. "Economical" is not quite the right word, because he was not so much interested in economy at this time. His nightmare was "shutdowns." It was only after receipt of the Standard Questionnaire from the Fuel Administration that economy attracted his attention.

The plant contained three 250-hp. water-tube horizontally baffled boilers. They were equipped with flat grates and the coal was burned by forced draft. The average combined efficiency of boiler and grate varied from 48 to 51 per cent. This was not unusual, but is a fair example of the operating efficiency of the average industrial-plant boiler room. The dry flue-gas loss and the unburned carbon loss in the ash were high. Stack temperatures ran about 600 deg. F. and the average CO_2 in the flue gases showed about 4 per cent. Coal weights and production figures taken over a period of a week showed that approximately one ton of finished product was produced for every ton of coal used.

The grates were of the pinhole flat type. The function of a grate is twofold; namely, a mechanical means of supporting the fuel bed so that air may enter it from beneath and pass through it with the least resistance to its flow. The pinhole grate admirably fulfills the function of supporting the coal, but its 7 per cent. air space builds up such a resistance to the flow of air that the grate fails in its purpose. In this plant we find the peculiar situation where turbo-blowers were trying to force air through the bed, and pinhole grates with 7 per cent. air space were trying to keep it out. Furthermore, the pinhole opening produces a nozzle effect upon the air passing through it, so that as the air strikes the bed it has reached its maximum velocity and tends to blow fine coal off the bed and back into the combustion chamber. For this reason an apparent combustion rate of 18 lb. per sq.ft. of grate per hour may represent an actual combustion rate of only 10 lb. This is what happened at this plant.

Shaking Type of Grate Selected

Grates of the shaking type which gave 30 per cent. air space were selected. If the matter of the selection of grates was to be done over again, there is no doubt that the choice would be a grate of the pyramid type. The writer believes that in this grate we have the nearest approach to the ideal condition; namely, a mechanical support which prevents leakage, 30 per cent. air space permitting unimpeded flow of air, a reduction in velocity instead of an increase as the air reaches the fuel bed, a preheating of air as it strikes under the grate surface and a consequent cooling and preserving of the grate, a lateral deflection of the air as it passes through the bed instead of a straight vertical jet.

It was surprising to see that there were no uptake dampers either in the flue neck of the individual boilers or in the main stack. When the manager's attention was called to this, he innocently remarked that there had been dampers at one time but they were taken out because the boiler room would fill with gas when the automatic regulator closed the dampers.

Damper Regulation and Control

Damper regulation is dependent upon the condition of the fire bed and entirely independent of boiler pressure. In a forced-draft installation the function of the damper is to maintain the draft over the fire at about —0.05 in. of water. As holes burn in the fire bed, air rushes through more readily and there is a tendency to build up a pressure over the fire. If such a pressure actually exists, the flames and gas are forced out into the boiler room. To maintain the slight vacuum desired the damper is opened a notch or two as the pressure builds up in the furnace. A high vacuum over the fire is undesirable because of possible inleakage of cold air through the settings if the latter contain many cracks.

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*Engineer, Fuel Engineering Co. of New York.

After investigation, it was decided that the proper draft conditions at this plant for the efficient combustion were: Ashpit, +1.2 in. water; furnace, —0.05 in. water. As the fire burns and holes appear in the fire, the ashpit pressure will decrease and there will be a tendency for the pressure to build up in the furnace. Proper adjustment of the uptake damper and the blower must be made from time to time to obtain the proper conditions. The plan of firing little and often was also introduced.

Referring to Fig. 1, the rate of burning of the coal is a function of the pressure drop through the fuel bed, or the difference between the ashpit and furnace pressures. When this pressure drop is at its maximum, as at *A*, the air supplied will efficiently burn a certain definite amount of coal per square foot of grate per hour. If more coal or less coal than this is fired, the result is either a smothering effect and incomplete combustion or a large excess of air and a cooling effect. As the fire burns out, the air rushes through more readily and the ashpit pressure falls off. At this time there is a tendency for pressure to build up in the furnace. Such a condition is represented at *B*, and the small pressure drop at this point indicates that the combustion rate of the coal has been materially decreased and that the large volume of air passing through the bed is seriously cooling the stack gases.

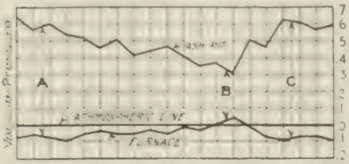


FIG. 1

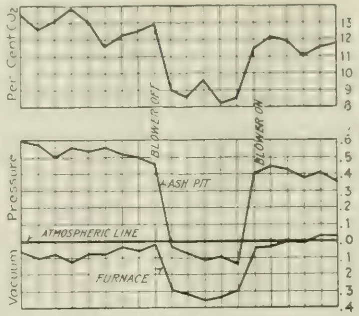
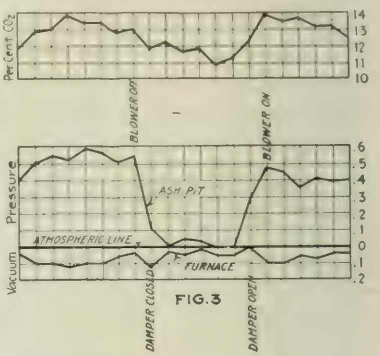


FIG. 2



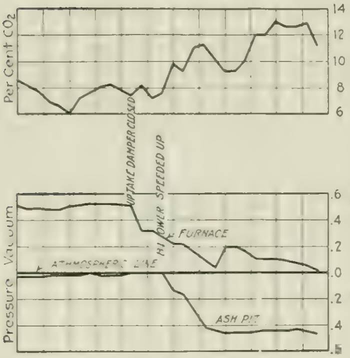


FIG. 4

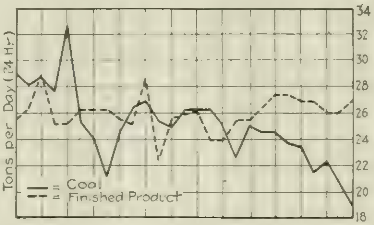


FIG. 5

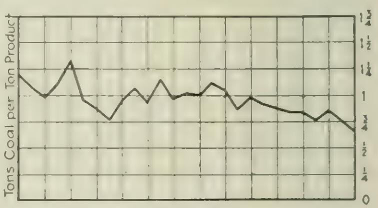


FIG. 6

CURVE STUDIES IN BETTERING THE PERFORMANCE OF AN INDUSTRIAL POWER PLANT

Now let the fireman coal up again at *C*. In doing this he covers the holes in the fire and a resistance to the air flow is again built up, which is evidenced by the increase in the ashpit pressure. There is also a tendency for the vacuum in the furnace to again be restored, and it may be necessary to adjust the uptake dampers to bring this down again to a balanced condition. The necessity of keeping the holes covered and of firing little and often is obvious. The practice at this plant was to smother the fire with 500 or 600 lb. of coal at a time and then sit down to rest for half an hour.

The dampers were restored to their proper places but not connected to the automatic regulator. Instead, the blowers were to be automatically controlled by means of a balance valve, and the dampers to be hand operated *as the conditions of the fuel bed demanded.*

Before the dampers were installed, the draft conditions due to the intermittent operation of the blower are represented in Fig. 2. Twenty-five per cent. of the time the blower was cut off. During these periods a heavy vacuum existed, not only in the furnace, but also in the ashpit, tending to suck in cold air through all cracks. During these periods the flue-gas temperature fell to about 300 deg. F., or 50 deg. cooler than the water in the boiler. It was not practical to cut one boiler out of the line, because the load was varied and uncertain.

After the dampers were properly installed and intelligently used, conditions were much improved. The resulting draft regulation is shown in Fig. 3. It was noticed that during the periods when the blower was cut off, the flue-gas temperatures reached a minimum of about 360 deg. This exclusion of the cold air from the boilers enabled the furnace to retain its heat for a longer time. For this reason the blowers were silenced for a much longer period and the fireman's work was much easier. In this way he accomplished exactly what he had tried to do by firing five or six hundred pounds of coal at a time and then resting. Besides this, the coal pile benefited considerably as will be shown later.

It was interesting to note the relation of percentage of CO_2 in the flue gas and the regulation of the draft during the observations at this plant. Fig. 4 shows the results of one of the preliminary observations. With a low ashpit pressure and the damper wide open, giving a high vacuum over the fire, the percentage of CO_2 in the flue gases was low. By speeding up the blower and closing the dampers a few notches, the same pressure drop through the fire bed was maintained, insuring the same combustion rate, while the CO_2 was increased to a desired value.

The boiler settings were made tight.

When the load was heavy, the flue-gas temperatures were about 600 deg. and sometimes went as high as 700 deg., indicating that the gases were being short-circuited through the boiler, or that the boiler was dirty. Both conditions happened to exist, and after a good overhauling this average temperature was reduced to 500 deg. F.

As a result of our efforts the daily coal consumption was reduced from 30 tons to 18 tons. Such a large saving was possible only because of the very wasteful condition of the plant in the beginning. The combined efficiency rose from 48 to 70 per cent., which is a good standard operating efficiency for any industrial plant.

MORE PRODUCTION WITH LESS COAL

During this work of coal conservation or, properly speaking, plugging leaks, the production at the plant was boosted to about 6 per cent. above its former point. In addition the coal mixture was reduced from 1 to 1 to 2 to 1. A further reduction to 3 to 1 was entirely successful, but the management was forced to call a halt because the supply of screenings ran low. The real test of the success of all these investigations was found in the office record. Formerly, one ton of coal was required for every ton of finished product turned out. At the present writing, a ton of finished product is being made for every five-eighths of a ton of coal, and the investigations are not yet finished. Fig. 5 shows graphically the relation between the production and coal tonnage of the plant. It is interesting to notice how the coal curve is on the decline. Fig. 6 shows that the curve of the ratio of tons of product per ton of coal is also on a similar decline.

The unburned carbon loss was reduced from 15 to nearly 3 per cent., which reduction was also partly due to greater care in cleaning fires. Still there was room for improvement. The CO_2 remained about $6\frac{1}{2}$ per cent. average. This coking method of firing was found to be the most satisfactory in this plant. By this method the CO_2 was boosted to an average of 8.5 per cent., and after the settings had been made tight and proper draft regulation secured by means of uptake dampers, the average CO_2 was 10 per cent.

SUMMARY OF CHANGES MADE

To sum up, then, the work at this plant involved:

1. Replacing the pinhole grate with a grate of proper design for the coal to be burned.

2. Installing uptake dampers and operating them by hand independent of automatic regulators. The blowers were then connected to the regulator.

3. Installation of draft gages and recording flue-gas thermometer. A CO_2 recorder was vetoed by the manager, but we have not given up hope.

4. Changing the method of firing from the "complete smothering method" to the "coking method."

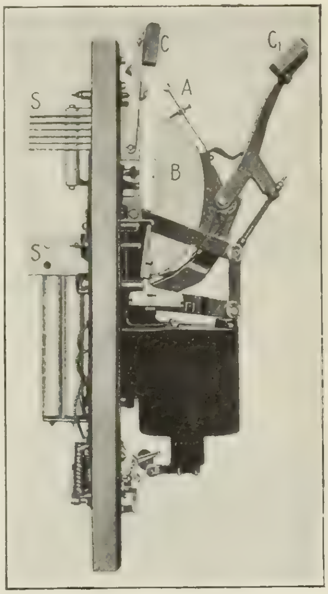
5. Maintaining proper draft regulation involving a balanced condition over the fire.

6. Overhauling boilers and settings and putting them in good condition.

With regard to the question of instruments the idea is erroneous that consistent saving of coal can be made or increased economy effected without instruments.

New Type of Reclosing Circuit-Breaker

The figure shows an electromagnetically operated circuit-breaker built in 3000- and 4000-ampere capacities. This breaker is closed and held closed by means of an electromagnet, opens automatically in case of overload, short-circuit or voltage failure and remains open a definite time interval regardless of the cause of opening. In case the breaker is opened by a short-circuit, it will make no attempt to reclose while the trouble exists, but closes instantly upon the removal of short-circuit or overload. The main contact brush *B* is of a laminated-butt-contact type. The studs *S* are of laminated construction, the lower stud being slotted vertically and the upper horizontally. The main contact brush *B* is protected from arcing by an auxiliary copper contact shunt *A*, and the final arc is taken care of on the upper graphalloy contact tips *C* and C_1. The upper arcing tip *C* is carried on a pivoted support actuated by a strong compression spring so that it follows out at a considerable distance in opening, thereby insuring good contact of the arcing tips until the brush and auxiliary contact are separated from their respective contacts. The upper rear arcing tip *C* is also pivoted directly on its support so that it is free to align itself with the front contact C_1 in all positions. Provision is made for adjusting the tension of the main brush by means of an eccentric bushing in the brush support.



CIRCUIT-BREAKER IN OPEN POSITION

This breaker is built by the Automatic Reclosing Circuit-Breaker Co., Columbus, Ohio, and is particularly adapted to heavy-duty work such as is met with in steel mills and street-railway service.

One of the greatest forces of civilization has been the utilization of power to do necessary and useful work for mankind. The importance and dignity of generating and delivering power service in a usable and helpful manner should not be underestimated by those who make the doing of modern marvels possible. Every man's work is needed, and it must needs be done well or the quality of the entire output is affected.

How Spacing and Thickness of Brushes Affect Commutation

By WARREN C. KALB
Managing Engineer, Corliss Carbon Company

Discusses how the spacing, alignment and thickness of brushes may cause circulating currents to flow in the armature windings and thereby develop poor commutation.

IF GOOD commutation and cool operation are to be secured, it is necessary that the brushes be accurately spaced around the commutator. If the spacing is unequal, it is impossible to so shift the rocker arm that all the brushes are brought into the best commutating position at one time. When some of the brushes are placed in the proper position, those on another stud may be located ahead of the neutral position. Brushes on still other studs may be located back of the neutral position, causing poor commutation. Unequal spacing of the brushes also puts an unequal number of turns in the different multiple paths through the armature. This is illustrated in Figs. 1 and 2.

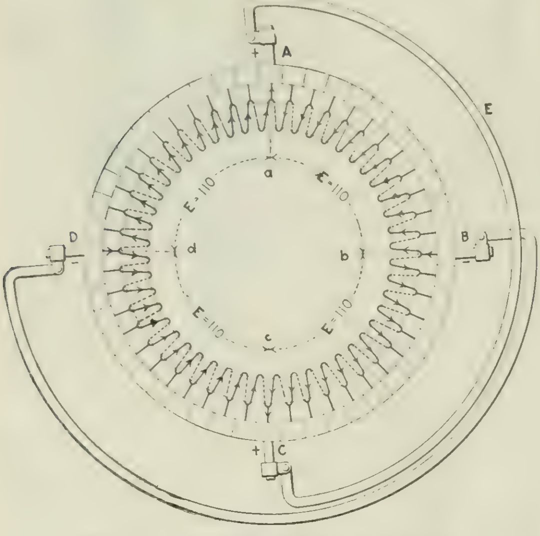


FIG. 1. BRUSHES EQUALLY SPACED

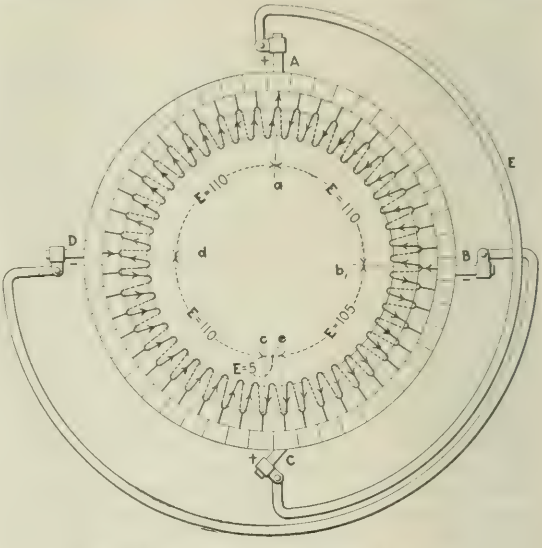


FIG. 2. BRUSHES UNEQUALLY SPACED

In Fig. 1 the brushes are equally spaced and have equal voltages generated in the winding located between them, so that the 110 volts generated in the section between brushes *A* and *B* is opposed by 110 volts between *B* and *C*, likewise the 110 volts generated between *A* and *D* is opposed by 110 volts between *C* and *D*. Consequently no current will flow from brush *A* to brush *B*, which is just as it should be; if there were, we would have current circulating in the armature when there was no load on the machine.

Assume a condition as in Fig. 2 where brush *C* is shown displaced on the commutator to a position *e*. In this position assume there is only 105 volts generated between brushes *B* and *C*. This leaves a difference of 110-105 = 5 volts, available to cause a current to flow through the section of the armature winding *eba*. Now consider the left-hand side of the winding. Between brushes *D* and *A* there is 110 volts of a direction to cause a current to flow from brush *A* around to *C*, then to the left through the section of the winding *eda*. The voltage between points *d* and *a* is in the same direction as the volts between points *e* and *c*, consequently there is 110 + 5 = 115 volts opposed by only 110 volts in section *d c*. Therefore in the left-hand section of the armature we have 115 — 110 = 5 volts available to cause a current to flow from brush *A* around to brush *C* through the sections of the winding *e c d a*. In other words, there exists a difference of potential of 5 volts between brushes *A* and *C* to cause a current to circulate in the armature windings. The resistance opposed to this unbalanced voltage is very low, being merely that of two brush contacts, one-half the armature winding and the busbar *E*. This total resistance is so low that very small differences in potential can set up excessive circulating currents through the armature and brushes, resulting in severe overheating of the armature and sparking and glowing of the brushes. Tests have shown that the value of this current may exceed the full-load current.

With cast-in polepieces it is not uncommon to find the poles unevenly spaced around the frame, and the results in such cases are similar to those obtaining with unequally spaced brushes. The fault cannot be corrected by matching the brush spacing to the inequalities in the pole spacing. It can be overcome only by trimming the edges of the pole faces in such a way that the flux is given a symmetrical distribution around the frame.

With a series-wound armature uneven spacing does not result in circulating currents through the entire armature winding since there are no multiple paths in which such currents can flow. However, heavy local currents may be set up in the coil short-circuited by two adjacent brushes of the same polarity and their connecting bus.

Brush studs may at times be found unequally spaced when a machine comes from the manufacturer. However, this condition is quite the exception. One of the most common causes for inequality in brush spacing is found on machines having the holders clamped on round studs. Rocking the holder toward or away from the commutator changes the point at which the brush bears. Carelessness in setting the holders at different angles to the commutator may result in pronounced inequality in brush spacing. This is the condition illustrated in Fig. 2, where the brush studs are evenly spaced and the inequality in brush spacing is due entirely to the different angles at which the holders are set.

Brush spacing may be checked up by counting the number of bars in the commutator, dividing by the number of poles on the machine and seeing that this number of bars is between corresponding edges of brushes on all studs around the machine. This method is troublesome, however, where the span is not an integral number of bars. A better method is to cut a strip of paper or other nonelastic material to the exact length of the commutator circumference, mark it off in equal parts corresponding to the number of poles and secure it around the commutator. The brushes on all studs can then be set by these marks and equal spacing insured.

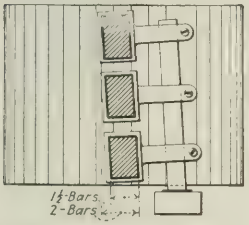


FIG. 3. BRUSHES OUT OF ALIGNMENT

Of equal importance with brush spacing is correct alignment of brushes with the commutator segments. Incorrect alignment is illustrated in Fig. 3. It may be due to poor alignment of brush studs, twisted commutator, or brush-holders set at different angles on the same stud. The effects are usually two-fold. Unless all studs on the machine are out of line in the same direction and by the same amount, unequal spacing of the brushes will exist with the results that have previously been described. An even more troublesome result may be the increase in the effective thickness of the brushes on the same stud. In the illustration the thickness of a brush is such as to span 1½ bars of the commutator but, due to the angle of the stud to the commutator segments, the three brushes span two full bars and the effect, as regards commutation, is the same as though a brush thick enough to span two bars were used. Where the brush thickness is originally chosen as large as the commutating characteristics of the machine will permit, bad commutation is an avoidable result of poor alignment.

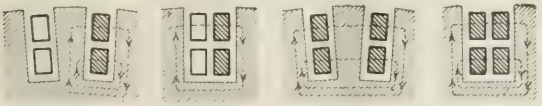


FIG. 4 FIG. 5 FIG. 6 FIG. 7.

FIGS. 4 TO 7. ARMATURE-WINDING SECTIONS

Assuming all mechanical conditions to be right and a brush free from all chattering or vibration, commutation is determined by the contact drop of the brush, its characteristic "sparking voltage" and the resultant voltage in the aramature coils short-circuited by the brush. By "sparking voltage" is meant the resultant voltage in the short-circuited coil below which no visible sparking occurs. The brush characteristic is somewhat different from contact drop. Of two brushes having the same contact drop, one may spark when short-circuiting a certain voltage, while the other does not. This is because the sparking voltage of the latter brush is higher than that of the former.

The voltage in a coil undergoing commutation is the resultant of several electromotive forces. The principal ones are: The voltage generated in the armature conductors due to the interpole flux or fringing mainpole flux; the volts generated in the end turns of the armature conductors due to whatever flux they may be cutting; and that due to self and mutual induction, commonly known as the reactance voltage. Opposed to this resultant voltage is the voltage drop across two contacts between the brushes and the commutator. The resistance of the armature winding and of the brush material itself is so small in relation to contact resistance as to be negligible in practically all cases.

Whatever affects the reactance voltage of a machine is likely to have a pronounced effect on its commutating characteristics. In Figs. 4 and 6 are shown sections of an armature winding with two coil sides per slot. Figs. 5 and 7 show four coil sides per slot. Conductors undergoing commutation are represented by shaded cross-section. In the case of Figs. 4 and 6 the brush covers only one commutator segment and only one pair of the conductors is shown undergoing commutation at a given instant. In Figs. 5 and 7 the brush covers two segments and two pair of conductors are undergoing commutation simultaneously. The reluctance of the magnetic path through the armature core being negligible as compared to that across the slots, the latter alone will be considered.

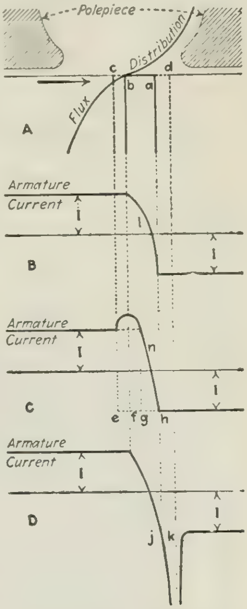


FIG. 8. FLUX DISTRIBUTION AND CURRENT CURVES

In Fig. 4 the slot is one-half as wide as in Fig. 5 and the magnetic flux encircling the conductors undergoing commutation will consequently be twice as great. The brush in both cases covering one segment, the time of commutation will be the same. As a result of these conditions the reactance voltage in Fig. 4 will be twice that in Fig. 5. In Fig. 6 the reluctance of the magnetic path is the same as in Fig. 5, but there are twice as many conductors carrying current, so the magnetic flux is doubled. In this case, however, the brush covers two commutator segments so the time of commutation is twice as long, equalizing the effect of the stronger magnetic flux and leaving the reactance voltage the same as in the case of Fig. 5. The same thing is true in the case of Fig. 7, where four coil sides are in the same slot.

Analyzing in a similar way the effects obtained with three or more coils, the following general conclusions may be drawn:

When the brush covers only one commutator segment, the reactance voltage is greater the narrower the slot.

The reactance voltage per coil remains unchanged, regardless of the thickness of the brush so long as the number of conductors simultaneously commutated does not exceed the total number of conductors per slot, as in Figs. 5 and 7.

The reactance voltage per coil decreases with increase in brush width where the number of conductors simultaneously commutated exceeds the number of conductors per slot, as in Figs. 4 and 6.

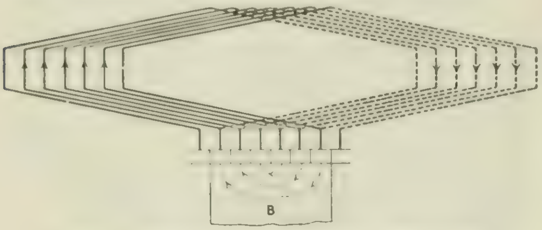


FIG. 9. BRUSH RESTING ON SIX SEGMENTS

The last statement would seem to impose no limitation on brush thickness so long as the number of conductors per slot is kept below the number undergoing commutation at one time. There are other limitations to brush thickness, however, which have to be considered.

In Fig. 8 is shown at *A* the flux distribution curve of a generator with a brush of thickness *a-b*, so placed that commutation begins just as the coil is passing through the point of zero flux. The brush thickness is assumed to be so chosen for the load in question, that commutation is completed just as the coil has come into a reversing field of sufficient strength to have established a current of like value but opposite direction to that flowing in the coil before commutation began. This represents a condition of perfect commutation and is illustrated at *B*, the curve there shown representing the current flowing in the coil under consideration.

Now assume a brush of thickness *a-c* shown at *A* Fig. 8, to be installed with its leading edge at the point *c*. The coil about to undergo commutation would, in this case, be short-circuited while it was still cutting a flux that would generate an electromotive force in the same direction as the current flowing in the coil. As a result the current would increase until a reversing flux was encountered, as shown in diagram *C* at point *f*. The current would not reach its original value until some time later, as at point *g*, so that the actual commutating interval would be reduced from the time *b-a* or *f-h* to the time *g-h* and commutation would not be as good as was obtained with the thinner brush. Should the thicker brush be shifted to the position *b-d*, conditions illustrated at *D* would obtain. Complete reversal of the current would be attained at the point *j*, but the coil would still be short-circuited and would be cutting a field of increasing strength. The short-circuit current might rise to a very high value before reaching the point *k* where one segment passes from under the brush. This high current would then have to drop suddenly to the value *I*, and an arc would be drawn between the brush and the commutator segment leaving it. The result is sparking of greater or less severity, depending on the value the short-circuit current had attained. Experience shows that the brush thickness should not exceed one-twelfth of the pole pitch projected on the commutator surface.

Another limitation to brush thickness is illustrated in Fig. 9, where the brush *B* is shown resting on six bars of the commutator and short-circuting five coils of the armature. It will be seen that from edge to edge of the brush there is impressed a voltage equal to the total of the resultant voltages in all the coils short-circuited. The resistance of the coils and of the brush material itself being negligible, the only resistance opposed to this voltage is that of two brush contacts. In order that an excessive voltage may not be short-circuited, a brush should not cover more than three commutator segments on an armature with a simplex winding. With a duplex winding it is permissible to cover twice as many segments, other conditions being equal.

In considering the effects of brush thickness and spacing on commutation, voltages set up in the coils undergoing commutation and circulating currents established in the armature conductors are the only points to which attention has been turned. The other factors influencing commutation (namely, contact drop and sparking voltage) are characteristics dependent on the brush composition and method of manufacture. The influence of brush spacing and thickness on these characteristics is so slight that it will not be given consideration in this article.

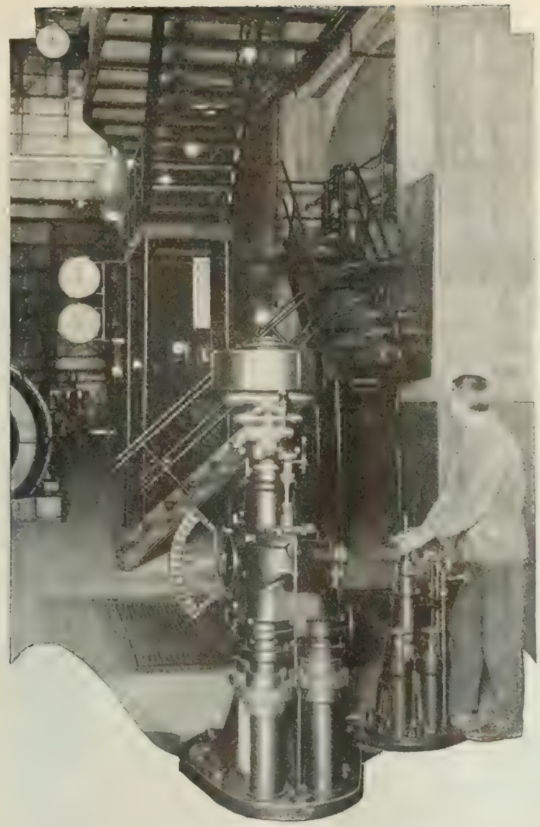
No nation under the sun has the trade literature available which is prepared regularly for the American people. No matter what line of industry, what branch of public service, or what profession one may be engaged in, there is a wealth of high-class authoritative literature which is up-to-the-moment. Sometimes workers and executives become so busy with the near-at-hand details that they do not realize what they are missing when they allow their trade or technical publication to gather dust or to remain in the wrapper. It is interesting to remember that each issue of a modern publication costs large sums of money for the editorial matter, the articles of specialized interest, the cuts, the illustrations, the departments of service and the market forecastings. All this is aside from the materials and labor which go into physical makeup and quite apart from the advertising pages, which constitute a world market place brought to your office. This service is all offered on the coöperative plan for the absurd price of a few cents per month for what has cost thousands to produce. Yes, it does seem as though *there is something* after all for almost nothing! Even then a technical publication will be of little value to its recipient unless it is read, digested and part of its experience and helpful suggestions acted upon. Columbus discovered America with all its wealth of mines and fields and forests and streams, but he died in chains in Spain nevertheless, because he did not possess what he had found.

Operation at Holtwood

STARTING AND STOPPING THE MAIN UNITS

By Charles H. Bromley

Describes the procedure and precautions used in starting and stopping the large main units.



SYNCHRONIZING A MAIN UNIT AT HOLTWOOD

UNITS Nos. 1 to 5 at Holtwood are each of 13,500 hp. capacity, while units 6, 7 and 8 are each of 17,000 hp. capacity. Units 1 to 5 were built for 53 ft. head, while units 6 to 8 were built for 63 ft. head. Units Nos. 1 to 7 have double runners, while the last, or No. 8, unit has a single runner.

Normally, all turbines are started on hand control. The governorman first ascertains that the hand control valve is closed. He next opens the two hand-control balance-pipe valves located on the hand-control pedestal. He now opens the hand-control valve until the gates are about 30 per cent or even 40 per cent open, for a few seconds, so as to accelerate the unit as quickly as possible; then he closes the gates to approximately 5 per cent., followed by carefully opening them to about 10 per cent., the object being to get the unit at about 95 per cent. speed and then to let it pass to the normal speed mark, 94 r.p.m., slowly, so that the operator does not fail to get a shot in the least possible time. While doing this he watches the large (18 in.) illuminated-face synchronoscope mounted midway of the turbine room and visible from all hand controls from No. 1 to No. 8 machine (See the headpiece at the top of the page).

In the meantime the switchboard operator orders the generator disconnectors closed. The field, even on idle machines, is always adjusted for approximately normal voltage and is closed immediately after but not before the machine starts to revolve. For the guidance of the governorman the synchronoscope is cut in before the machine reaches the normal speed. Should the operator miss the first favorable shot, it requires from 10 to 20 sec. to restore normal speed, owing to the unit slightly overshooting the normal speed mark. Bad shots are not tolerated at Holtwood as they may induce severe water-hammer in the governor system and are injurious to the generator and generator leads.

The time of starting a machine ordinarily is not over a minute. The record time of starting from standstill to synchronizing on the board is 26 sec. made on No. 2 machine.

Transferring from Hand Control to Governor Control—When the unit is synchronized with the bus, it is transferred from hand to governor control. First, the governor pressure valve above the accumulator tank is

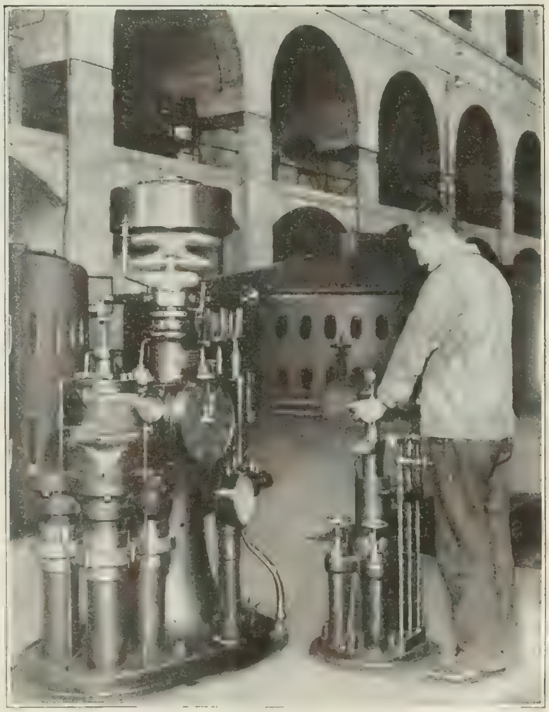


FIG. 1. CHANGING FROM HAND TO GOVERNOR CONTROL

opened and the governorman observes that the setting of the governor corresponds with the gate opening. The two hand-control balance pipe valves are now closed and the two generator balance pipe valves opened. The second valve is opened gradually at first as slight changes in adjustment may be necessary to the governor if the gate opening changes. The governorman now observes if the governor-control motor gear is engaged.

The collar jack-nut on the governor spindle is now run up until it is about one-quarter inch from the collar. From time to time as the load changes appreciably, the jack will have to be moved up or down; it is not permitted to be closer to the collar than one-quarter inch.

The governorman now signals the operator that the unit is under the governor control.

Transferring from Governor Control to Hand Control—The hand-control valve is set to correspond with the gate opening. Now the two balance-pipe valves are closed and the two hand-control valves are opened. The unit is now on hand-control.

The governor-pressure valve above the accumulator tank is closed. The governorman is seen making the transfer in Fig. 1.

When the unit is on hand-control the governorman or his assistant must be standing by to respond to the operator's signal to care for the machine in case of a runaway.

Shutting Down the Turbine—The operator drops the load on the machine and cuts out the generator oil switch. He then gives a stop signal upon which the governorman transfers the unit from the governor control to hand control, closing the gates and stopping the machine with a brake if necessary. Use of the brake in stopping the machine is necessary in order that the main thrust bearings for the mainshaft may not run at too slow a speed, thereby failing to get adequate lubrication.

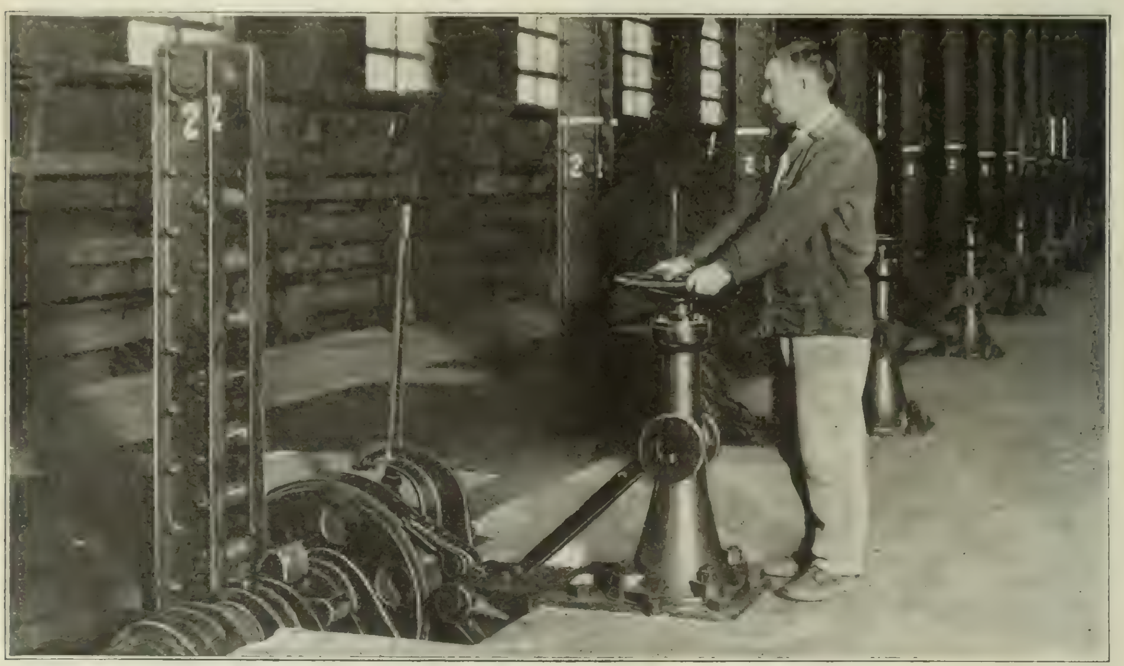


FIG. 2. OPERATING THE HEADGATES BY MEANS OF MOTOR AND BRAKE

While there is little hazard on account of a runaway generator, efforts are made to stop the machine immediately. Usually, such a runaway can be slowed to normal speed by operation of the governor or by hand control. Cutting in the large water rheostat on the runaway machine through the auxiliary bus and then closing the field switch will assist in stopping the runaway.

In case the governor is the prime cause of the runaway brought about through the spindle guide-bearing burning out or through stripping of the gears, sticking of the regulating valve, etc., a change is at once made to hand control. Should control of gates be lost, the unit must be slowed down by closing the headgates. This can be done rapidly on the gatehouse floor by releasing the holding brakes of the headgates, as shown in Fig. 2.

Should it happen that the generator with bad gate control cannot be spared, it is left on the auxiliary bus in parallel with the system, the water rheostat being kept ready to be thrown on the bus so that sudden loss of load will not permit the generator to run away.

If the gate control on a generator is lost and the machine is needed for service, it is cut in and paralleled with the system by means of the headgates. After the wheelpit is filled with water, it is necessary only to raise one of the gates a small distance to keep the machine at speed until it is synchronized. When synchronized, its regulation is had by operating the headgates. One gate only is used if it will pass enough water to permit the turbine to carry the load; if not, two are opened. A man to operate the gate is, of course, stationed in the gatehouse during such times.

Synchronizing from Benchboard Without Any Attendant on Main Floor—The benchboard operator is also in a position to start a unit from standstill, bring it up to speed, and synchronize it single-handed from the benchboard gallery without the assistance of any governor attendent on the main floor. This is accomplished by the use of the electric speed control provided for each generator on the benchboard, but requires, of course, that such a unit is on governor control when starting from standstill and that the air brakes, generally used for stopping a unit, had been released since the last shutdown. The speed of the unit does not respond as promptly to the benchboard control of the governor as to the more direct hand control. This method of starting up and synchronizing a unit without any floor attendant is rarely resorted to in the regular course of operation, as it requires a somewhat longer time than any other method in use. Depending on the dashpot adjustment of the governor, operators have been able to synchronize a unit in this manner from standstill in 96 sec. with the bypass open only a quarter of a turn, and even in as short a time as 65 sec. when the bypass was open two full turns.

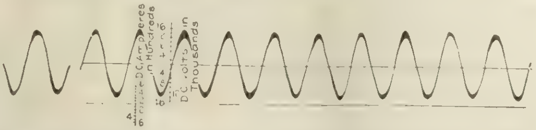


FIG. 3. VOLTAGE WAVES OF THE SYSTEM BUS AND THE INCOMING GENERATOR WHEN CAREFULLY SYNCHRONIZED

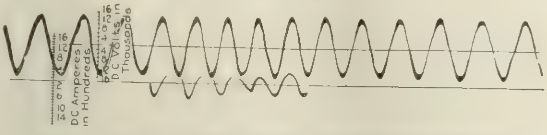


FIG. 4. BUS AND INCOMING GENERATOR WAVES, GENERATOR OUT OF PHASE 22½ DEGREES

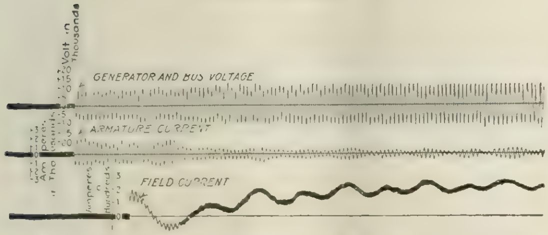


FIG. 5. OSCILLOGRAM MADE WHEN A UNIT IS PULLED INTO SYNCHRONISM AS AN INDUCTION MOTOR

Paralleling a Single Unit Without Synchronizing—At Holtwood the emergency may arise, especially during low-flow season, when a considerable portion of the load is carried by steam, that some unexpected trouble may develop in one of the three or four steam stations that may operate in parallel, and then it is imperative to pick up 10,000, 15,000 or even 20,000 kw. immediately. The normal method of synchronizing the needed generators is dispensed with at such a time. The slightest sign of any station being in distress, as indicated by drop in frequency, is the signal to cut in generators until the frequency is restored to normal. The operator displays the "Start" and "Fast" signals to the governorman, indicating that the unit is to be brought up to speed with all possible haste; he orders the generator disconnectors closed. As soon as the speed of the unit is approximately normal (within 5 per cent) the generator oil switch is closed, which causes the generator to operate as an induction motor and pulls the unit into synchronism. A moment later the generator field switch, which had been open from the last shutdown of the unit, is closed. The gates are opened, and the generator immediately picks up its quota of the load and brings the frequency to normal. The actual voltage disturbance resulting from such procedure does not exceed a momentary decrease of 4 per cent. to 8 per cent. and the load is not affected.

The time required to get a unit under load by this method is the time required to accelerate the machine and to get the generator oil-switch disconnectors closed. The rotating elements weigh 450,000 lb. each and the flywheel effect (WR^2) is 13,000,000 ft.-lb. The acceleration of the machine takes about 40 sec. and the closing of the disconnectors varies from 25 sec. to 50 sec., depending upon which unit is started and the distance its disconnectors are from the benchboard. When a large portion of the system load is being carried by other stations, the time required for closing the disconnectors is practically eliminated by having all disconnectors previously closed. In this case it is arranged that there are two open oil switches between the generator and the bus so that the accidental closing of one oil switch would do no damage. The generator itself is allowed to drift on vane leakage, or one unit may even be permitted to run at normal speed, thus eliminating the time required for acceleration.

Paralleling Several Units Without Synchronizing—An emergency condition may also occur when it becomes necessary to parallel several, or even all, units in the station in the shortest possible time. This can be done rapidly by closing in on the bus all generators, the field breakers of which had been tripped previously, and then simultaneously closing all the fields. The latter opera-

FIG. 6. THE GENERATORS AT HOLTWOOD

tion is done with a master field switch provided for the purpose. This method is resorted to only in the event of an interruption to service, when voltage is to be restored quickly to the bus or to the transmission lines.

Fig. 3 shows the voltage waves of the system bus and the incoming generator when carefully synchronized. The two waves appear as one, and no current disturbance occurred when the oil switch of the generator was closed.

How the waves appear when the bus and the incoming generator are considerably out of phase is shown in Fig. 4, where the generator was 22½ deg. out of phase There was violent disturbance when the oil switch pulled the wave into coincidence with the bus wave.

Fig. 5 is an oscillogram showing the effect of paralleling a single unit without synchronizing, the unit being pulled into synchronism as an induction motor.

Chart for Boiler-Test Results

BY HERBERT B. REYNOLDS

All the lengthy calculations involved in working up the results of a boiler test in order to determine the evaporation per pound of fuel, the equivalent evaporation or the boiler horsepower may be dispensed with and the results found directly from the chart that forms the supplement to this issue.

ALTHOUGH the computations involved in obtaining the results of a boiler test are not at all complicated, they are more or less laborious due to the fact that they cannot be performed by a few consecutive slide-rule operations. In order to avoid these computations, and to save time and labor when there are a great many tests to be computed, the accompany chart has been devised. (See insert.)

The method of using the chart can be illustrated best by assuming an example. Suppose that the averages obtained from a given boiler test are as follows:

Absolute steam pressure, lb. per sq. in.	215
Superheat, deg. F.	140
Temperature of feed water, deg. F.	180
Feed water per hour, lb.	40,000
Moist coal fired per hour, lb.	4,600
Per cent. moisture in coal	2
Heating value of dry coal, B.t.u. per lb.	14,000

The solution of this problem is indicated by the dotted line on the chart, starting on the base line of the upper right-hand quarter of the diagram and proceeding around in a counter-clockwise direction through the remaining sections.

The average boiler pressure observed during the test is 215 lb. per sq.in., absolute. So, on the base line of the upper right-hand quadrant locate the point midway between 210 and 220, corresponding to 215 lb. per sq.in., and proceed vertically to the line marked 140, which indicates the degree of superheat of the steam.

From this point follow a horizontal line to the left, into the upper left-hand quarter of the diagram, until the diagonal line marked 180 is reached, this line indicating a feed-water temperature of 180 deg. F. Then drop vertically into the lower left-hand quadrant. This vertical line will cut the base of the upper left-hand quadrant at a point corresponding to 1.166, and that value is therefore the factor of evaporation for the steam and water conditions observed during the test.

Continue the vertical line until it strikes the inclined line marked 40,000, which is the weight of water evaporated per hour. Proceeding horizontally to the left from this point to the scale at the left-hand edge of the diagram, the equivalent evaporation will be found to be approximately 46,700 lb. per hour. On the other hand, proceeding horizontally to the right to the right-hand edge of the lower left-hand quadrant will show the output in boiler horsepower, which in the case under consideration is 1355.

Continue the horizontal line to the right until it intersects the diagonal marked 4600, corresponding to the number of pounds of coal fired per hour, and then turn vertically upward to the middle horizontal line of the diagram, where the scale will be cut at a point indicating 10.1 lb., the equivalent evaporation per pound of fuel fired.

But the fuel contained 2 per cent. of moisture. So, from the intersection of the vertical line and the diagonal line representing 2 per cent. of moisture in the fuel, proceed horizontally to the right, where the vertical scale will be cut at a point representing 10.3 lb., the equivalent evaporation per pound of dry fuel. Continue still farther horizontally to the right, to the diagonal marked 14,000, representing the heat value of the fuel used, and then follow vertically to the scale on the lower side of the middle horizontal line, where an over-all efficiency of 72 per cent. will be indicated.

In the upper right-hand quadrant one of the curves is marked Saturation Line. This line represents zero superheat, as marked, and is the line that must be used in case the steam is dry and saturated. If the steam contains 1 per cent. of moisture, use the line marked 0.99, corresponding to a quality of 99 per cent.; and if there is 2 per cent. of moisture in the steam, its quality is 98 per cent. and the line marked 0.98 must be used.

There is scarcely a day goes past when each one of us does not glimpse or even catch hold of a good idea somewhere. It may be how to tie one's cravat more deftly; or a soap or tooth paste that will prove more satisfactory; or a little twist, or turn, projection or indentation, that will make a machine run more smoothly. It may be an idea concerning any one of ten thousand things. If we let it get away from us, the chances are that the next good idea will be a little more elusive and difficult to grasp, and so we will cultivate the habit of unresultful mental attitudes. Thousands of fortunes are lost every year because good ideas are let go a-glimmering. One good idea put to work is worth while, and the beauty of it is that it makes us more capable to catch and use other good ideas, and further than that, it makes us more alert and more discriminating as to which ideas are good and which are good for nothing.

A cement for securing leather lagging to iron pulleys can be made by adding to one quart of glue, dissolved in good cider vinegar, one ounce of venice turpentine. Allow it to simmer over a slow fire for about half a day and apply with a brush, then put on the leather and allow to dry for about two hours.

Scavenging in Two-Stroke-Cycle Diesel Engines

By NICHOLAS M. TRAPNELL

The purpose of scavenging is to clear the cylinder of burnt gases at the end of the power stroke and to fill it with fresh air ready for compression. This article describes methods of scavenging and types of scavenging pumps.

SCAVENGING in the two-stroke-cycle Diesel engine is accomplished by admitting air, at a pressure of from 3 to 6 lb. per sq.in., to the cylinder in such a manner that it forces the products of combustion out through the exhaust ports and fills the cylinder with air ready to be compressed on the next stroke of the piston. There are several methods of admitting the air to the cylinder. The first method used was by means of valves in the cylinder head, as shown in Fig. 1. As the piston *A* nears the end of the power stroke it uncovers the exhaust ports *B* in the bottom of the cylinder, which allows the exhaust gases to blow out into the exhaust pipe *C*. Shortly after the piston begins to uncover the exhaust ports, the scavenging valves *D* in the cylinder head open and allow the scavenging air to sweep down, forcing the products of combustion out through the exhaust ports and filling the cylinder with fresh air. The piston then starts on the return stroke and closes the exhaust ports after which the scavenging valves close and compression begins.

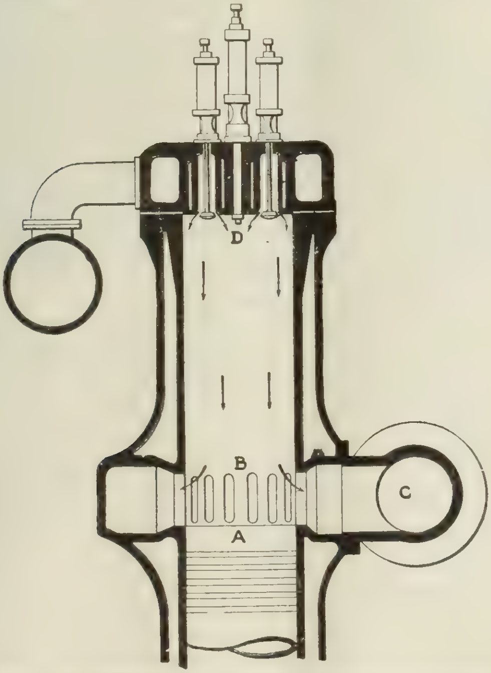


FIG. 1. SCAVENGING BY VALVES IN CYLINDER HEAD

The scavenging valves are usually set to open some time after the piston has begun to uncover the exhaust ports, so as to allow the pressure in the cylinder to drop nearly to that of the atmosphere before the valves open; otherwise there is danger that the exhaust gases will back up through the scavenging valves into the scavenging-air receiver. The valves are usually set to close shortly after the piston has closed the exhaust ports, thereby allowing the pressure in the cylinder to build up to that of the scavenging-air receiver and giving a slightly higher pressure at the end of the compression stroke than would be the case if the scavenging valves closed as soon as the piston closed the exhaust ports.

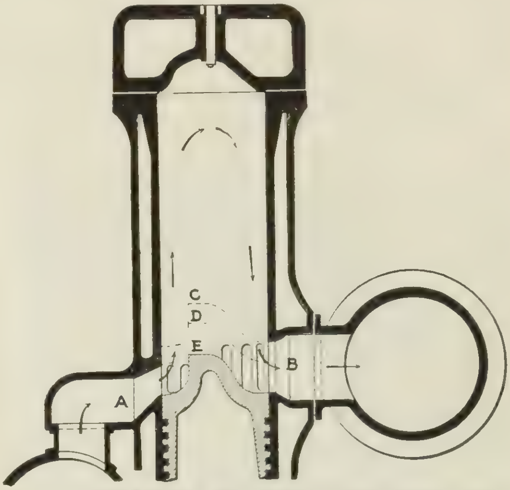


FIG. 2. SCAVENGING BY PORTS IN CYLINDER WALL

This method of scavenging is very rapid and efficient and is extensively used in the smaller engines; but, as a large valve opening is necessary to admit the required amount of air to the cylinder, usually two and often four valves per cylinder are necessary in the larger engines. This leads to excessive complication of the valve gear, especially in large engines, where six valves per cylinder would be necessary, including the fuel-inlet and starting valves. Also, the excessive number of valves greatly weakens the cylinder head, which should be pierced by as few openings as possible because of the high pressures and temperatures reached in Diesel-engine cylinders.

To overcome these difficulties a system of scavenging was developed which is now extensively used on large two-stroke-cycle engines. In this system, shown in Fig. 2, ports are used instead of valves. The scavenging ports *A* are arranged in the cylinder wall near the bottom of the cylinder, opposite the exhaust ports *B*. When the piston reaches the position *C* in the power stroke, it begins to uncover the exhaust ports *B* and allow the products of combustion to escape to the exhaust pipe. When the piston has reached the position *D*, the pressure in the cylinder has dropped nearly to that of the scavenging air and the scavenging ports *A* begin to open and admit the air to the cylinder. When the piston has reached its final position *E*, all ports are open wide. The incoming scavenging air is deflected upward by the shape of the piston, so as to drive out all the exhaust gases. On the return stroke, the piston first closes the scavenging ports and then the exhaust ports, after which compression takes place.

This system is slightly less efficient than the valve scavenging system, but it does away with all scavenging valves and greatly simplifies the engine, as only two valves are necessary per cylinder—the fuel-inlet and starting valves—and in some cases only one, in case the starting valve is omitted. With this system the combustion chamber is not of the most efficient form, because of the shape of the piston. It should be as nearly symmetrical as possible and should contain no pockets or cavities. Also the compression is not so high as might be, because the scavenging ports are closed before the exhaust ports, so that compression starts from atmospheric pressure instead of from 3 to 6 lb. per sq.in., as is the case where scavenging valves are used.

Fig. 3 shows the system of scavenging used on an engine of the two-stroke-cycle type. The combustion chamber is not distorted and the scavenging ports are allowed to remain open for a short time after the exhaust ports have been closed. The main scavenging ports *A* are arranged half-way around the circumference of the cylinder at the bottom, opposite the exhaust ports *B*. Directly above the main scavenging ports *A* are the auxiliary scavenging ports *C*. The admission of air to these ports is controlled by the auxiliary scavenging valve *D*, which is operated by an eccentric on the engine camshaft. The scavenging ports are inclined so as to deflect the air upward and thoroughly scavenge the cylinder.

As the piston *E* nears the end of the power stroke it first uncovers the auxiliary scavenging ports *C*, but no air is admitted through these ports because the valve *D* remains closed. It then begins to uncover the exhaust ports *B*, which allows the product of combustion to escape to the exhaust pipe *F*. When the piston has reached the end of the stroke, it has completely opened the exhaust ports *B* and also the scavenging ports *A*, thus allowing air to enter the cylinder from the receiver. At this time the valve *D* begins to open and admit air through the ports *C*. On the return stroke the piston first closes the main scavenging ports *A*, but by this time the valve *D* is wide open and air is still entering the cylinder through the ports *C*. Next, the exhaust ports *B* are closed, shortly after which the auxiliary scavenging ports *C* are closed. The valve *D* remains open until the ports *C* have been covered by the piston.

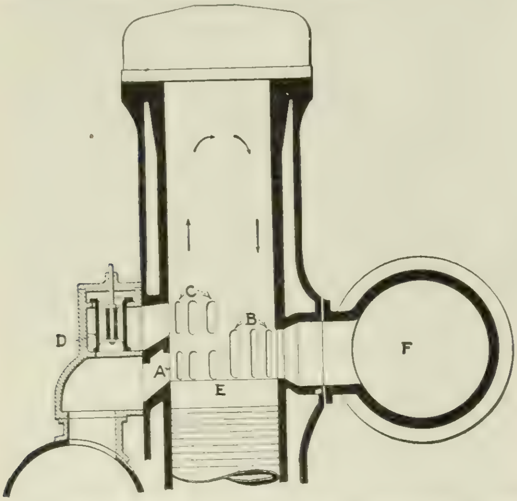


FIG. 3. SCAVENGING BY MAIN AND AUXILIARY PORTS

These three systems of scavenging are the ones generally used on two-stroke-cycle Diesel engines. There are a few other systems used, but they differ only in minor details from the ones described.

The air for scavenging is obtained from the scavenging pumps, which are of the low-pressure reciprocating type and have a large capacity. The pumps are usually driven by the main engine, either from the crankshaft or by means of levers and rods connected to the crossheads or connecting-rods. In marine work two pumps per engine are usually furnished, so that in case one breaks down the other will deliver enough air to keep the engine running, as each pump has about 60 per cent. of the total capacity required to run the engine.

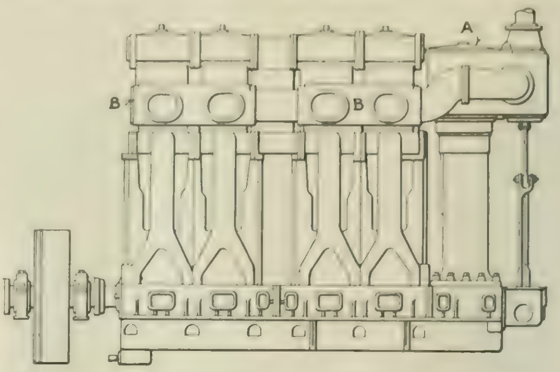


FIG. 4. ARRANGEMENT OF SCAVENGING PUMP AND AIR RECEIVER

The scavenging pumps discharge into a receiver, usually of small dimensions, which runs the whole length of the engine and supplies air to each cylinder for scavenging. This arrangement is shown in Fig. 4, in which *A* is the scavenging pump discharging into the receiver *B* which supplies air to the cylinders.

Very often large engines are divided into two sections; that is, a 4-cylinder engine is treated as two 2-cylinder engines and a 6-cylinder engine is treated as two 3-cylinder engines, one scavenging pump supplying each section. On very large double-acting engines one scavenging pump per cylinder is often used.

Fig. 5 shows a cross-section of a typical scavenging pump. The cylinder *A* is mounted on the engine frame and the piston *B* is driven by the beam *C*, which in turn is driven, through links, from the crosshead of the main engine. The air is drawn from the suction pipe *D*, through the suction valves *E*, into the cylinder *A*, and is discharged through the discharge valves *F* into the passage *G* which leads to the scavenging air receiver. The flat or grid valves commonly used in this type of pump are closed by their own weight or by light spiral springs. Air enters the suction pipe *D* through the vertical slots *H* in the cylinder *I*, which acts as a silencer and strainer.

In the designing of scavenging pumps, the most important point is the provision of an ample supply of air, but it is difficult to say what should be the exact capacity of the pumps relative to the working-cylinder volume. That it must be in excess of the latter is generally agreed. For ordinary marine engines and low-speed stationary engines of the two-stroke-cycle type, the volume of the scavenging pump is frequently made 25 per cent. greater than that of the working cylinder, while in high-speed engines it is often made 50 per cent. greater.

Lately, turbo-blowers have been substituted for scavenging pumps in a number of cases. The results have been satisfactory, as a properly designed turbo-blower is capable of delivering a large volume of air at a pressure high enough for satisfactory scavenging, and it will undoubtedly be used extensively in the future, because of its simplicity and ease of regulation.

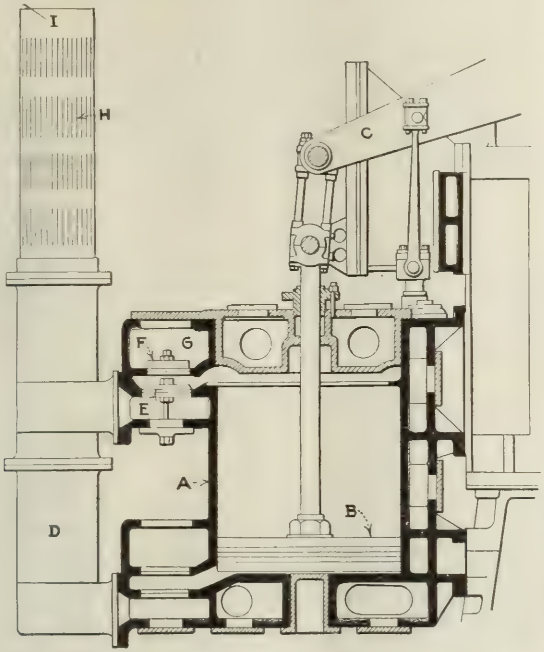


FIG. 5. CROSS-SECTION OF TYPICAL SCAVENGING PUMP

Lead-Burning Transformer for Small Storage Batteries

The most modern method of burning terminals in place on storage batteries, removing old connections, cutting off or building up posts, and in fact almost any form of lead work, is to do it by the electric-welding process. A lead-burning transformer, shown in the illustration, has recently been developed for small storage-battery work. This transformer is designed to be connected to the ordinary 110-volt alternating-current lamp socket, a 10-ft. cord with plug being provided for this purpose. Two separate rubber-covered terminal leads are used to convey the low-voltage heat-producing current to the parts of the battery to be welded. The lead having the "Big Brute" clip is for fastening to the battery plate or posts to be worked on; the other lead has at its end a carbon holder, which is arranged with a heavy insulated handle so that the operator's hand is guarded from the heat. The carbon holder takes an ordinary arc-welding carbon, this carbon forming the second terminal.

When the pointed arc-welding carbon is brought into contact with the lead, the pointed end becomes so hot that it melts the lead over a restricted area quicker than a pointed gas flame will do it. The welding or burning operation is carried out by a sort of puddling process, the carbon terminal being manipulated to flow the lead where needed.

One of the advantages of the appliance is that repair work in hard-to-get-at corners can be done more easily as the heat is always right at the point of the carbon. The device is readily portable, weighing approximately 25 lb. Joints do not have to be cleaned, as the dirt and slag automatically rise to the surface of the molten lead and the surfaces are joined while cleansed. When properly used, there is no glare to injure the operator's eyes, as he looks down on the cool end of the carbon in such a way that the bright point where the carbon touches the lead is hidden from view.

LEAD-BURNING TRANSFORMER ASSEMBLED AND IN USE

On the basis of 10c. per kilowatt-hour, it costs about 8c. an hour for current when the device is operating steadily. The instant the carbon point is removed from the work the current consumption practically ceases, as the device then takes only 4.5 watts from the line. The apparatus is especially valuable in reconstructing and repairing batteries, while in a shop and foundry it has been used where all kinds of odd soldering jobs must be done. It has also been found applicable in plumbing, roofing and tank building. This equipment is manufactured by the General Electric Co., Schenectady, N. Y.

A paste metal polish is made from the following ingredients, which are sufficient to make 20 lb. Take 4 lb. of cake tallow, 2 oz. of spermaceti, 10 star candles; 2½ pt. raw linseed oil; 2½ pt. kerosene and 5 lb. tripoli powder. Secure a three- or four-gallon crock, put in the tallow, spermaceti and candles and melt over a slow fire. Then add the linseed oil and kerosene and stir well. While this mixture is still warm remove from the fire and slowly add the tripoli powder, continually stirring the mixture. Then allow to cool and apply with a soft cloth. After drying it can be removed by going over the polished surface with a dry cloth. This polish is good for either hot or cold smooth surfaces.

The Electrical Study Course—Prony Brake Test on Electric Motor

Describes the details of an efficiency test as made by means of a prony brake and illustrates the method with a numerical example.

TO MAKE clear the application of the theory regarding brake tests, as it was developed in the preceding lessons, an outline will be presented of the details of such a test as it would be conducted in practice. The procedure for the three types of motors, shunt, series and compound, would be practically the same, and since the shunt type is the simplest, it will be selected as the one to use in the example. The only points in connection with series and compound motors that require emphasis as differing from the conditions existing in the case of the shunt motor are, that the entire brake friction must never be removed when testing the series type, since it would then be operating at no load and would therefore run away, and that care must be exercised when testing the compound type that it is connected for cumulative excitation and not differential excitation unless the machine is specially designed to operate as the latter type.

Before presenting the test it will be well to review, in a few words, its purpose, which is to construct an efficiency curve from which the efficiency of the machine may be obtained for any load upon it, irrespective of whether a test of its efficiency was made at that particular load. For this purpose the efficiencies at various loads must be determined. Points are then plotted on cross-section paper, and through them is drawn a smooth curve, which is the efficiency curve desired.

To obtain the efficiencies at various loads, we must know the output and the corresponding input for each of the loads selected for testing, which are usually 25, 50, 75, 100 and 125 per cent. of the full-load current marked on the name-plate. The output is determined by means of the brake and the input by means of a voltmeter and an ammeter. Knowing the output and input for a given load, we can compute the corresponding efficiency, since

$$\textit{Efficiency} = \frac{\textit{output}}{\textit{input}}.$$

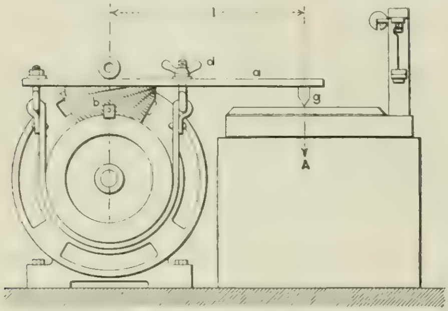


FIG. 1. MOTOR FITTED WITH A PRONY BRAKE

Assume that the motor to be tested is rated at 5 hp., 115 volts and 40 amperes and that it is to be tested by means of a prony brake such as that illustrated in Fig. 1; also that it has been fitted with a hollow pulley for water cooling. The first step would be to connect up the machine and instruments as shown in Fig. 2 and to start it, observing the direction of rotation, which should be such as to cause the brake to move downward; that is, in the direction *A* in Fig. 1. When it is found that the rotation is in the proper direction, the motor is stopped and the brake is adjusted to its pulley. The platform scale is then set under the contact edge *g* at such a height or a block of wood placed on the scale so that the arm *a* is level. The distance *l* is then measured if it is not already known. It is now necessary to find the weight recorded by the scale owing to the fact that it is supporting the brake at *g*. This weight plus the weight of the block of wood, if used, will have to be subtracted from the readings obtained when the pulley rotates, since it is merely the dead weight of the brake equipment and is not due to any force tending to push it in the direction *A*. It is understood that the reading must be taken while the nut *d* is slack. A more accurate method of determining the tare weight is to revolve the pulley slowly, first in one direction and then in the reverse, noting the reading of the scale in each case; the average of the two readings is the actual weight. The effect of any friction between the block *b* and the pulley, which might prevent the true weight from bearing on the scale, is thereby eliminated. A revolution counter or a tachometer will be required to measure the speed. Forms in which to record the readings should be prepared, after which everything would be in readiness to begin the test, which would be carried out as follows:

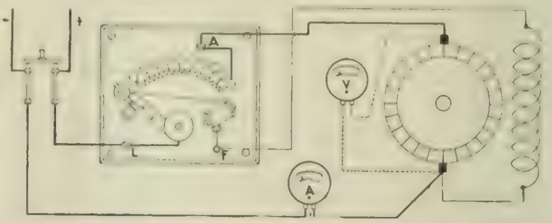


FIG. 2. SHUNT MOTOR CONNECTED TO STARTING BOX

Start the motor and pour a moderate quantity of water into the pulley. Then tighten down on the brake nut *d* until the current as indicated by ammeter *A* reads about 50 amperes which is equivalent to 25 per cent. overload. Allow the motor to run under these conditions for about one-quarter to one-half hour in order that it may become warmed up and thus be operating under conditions as nearly duplicating those found in practice as possible. The water in the pulley will quickly be raised to the boiling point and a cloud of steam will be found to issue from the pulley. As the water boils away it should be replenished from time to time so that the pulley shall never run dry.

After the machine is thoroughly warmed, the readings are to be taken. There will be five sets of them; namely, for 25, 50, 75, 100 and 125 per cent. of full-load current; that is, for 10, 20, 30, 40 and 50 amperes, and each set will consist of a reading of the voltmeter, the ammeter, the scale and the revolution counter. Therefore, to start, adjust the nut *d* of Fig. 1 until ammeter *A* of Fig. 2 indicates a current of 10 amperes, and make a record of all the readings. Then increase the tension until the ammeter indicates 20 amperes and again record the readings. Follow a like procedure for values of 30, 40 and 50 amperes.

When the last reading has been taken and the motor is ready to be shut down, loosen the nut *d* completely, hold the pail directly under the pulley and pull the switch. As the pulley comes to a stop, the water is no longer kept against the inside face by centrifugal force, and it will splash out into the pail. If the motor is shut down while there is tension on the brake the armature will come to a sudden stop, with the result that the hot water in the pulley will be apt to be thrown out more or less violently.

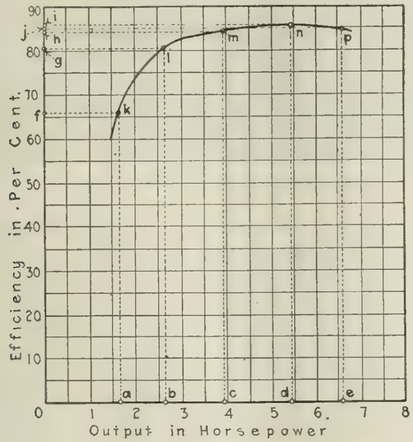


FIG. 3. MOTOR-EFFICIENCY CURVE

Let us suppose that the length *l* was measured and found to be 15 in., that the tare weight of the brake is 2 lb. 3 oz., and that the five sets of readings gave the results given in Table I.

TABLE I. READINGS OBTAINED FROM MOTOR

Reading No.	Volts *E*	Amperes *I*	R.p.m. *S*	Lb. Oz. *W*
1	118 0	10.2	1630	4—15
2	117.4	20 4	1590	9—01
3	116 9	30.0	1545	13—00
4	116.2	40.1	1495	17—03
5	115.4	49.8	1440	21 05

The input in each case is watts $= EI$. To convert into horsepower we divide by 746, so that, Input in hp. $= \frac{EI}{746}$. If we let S represent the speed for a given load and f the corresponding force registered by the scale, we have that the output is equal to $2 \times \pi \times S \times f \times l$ ft.-lb. per min. Dividing by 33,000 will give us horsepower; that is, Output in hp. $= \frac{2 \times \pi \times S \times f \times l}{33{,}000}$. The values of π and l are the same for all cases, so that we may substitute them in the formula, thus giving us, Output in hp. $= \frac{2 \times 3.142 \times S \times f \times 15}{33{,}000 \times 12}$, where the 12 in the denominator is introduced to convert l from inches into feet. Simplifying the expression gives, Output in hp. $= 0.000238 \times S \times f$. The value of f is obtained by subtracting the tare weight of the brake (namely, 2 lb. 3 oz.) from the weight W appearing in the last column of Table I. We thus have that, Output in hp. $= 0.000238 \times S \times (W - 2$ lb. 3 oz.).

Upon making the computations for the input and output for each reading we obtain the results contained in the second and third columns of Table II.

TABLE II. MOTOR'S EFFICIENCY AT VARIOUS LOADS

Reading No.	Input, Hp.	Output, Hp	Efficiency Per Cent,
1	1 614	1.067	66.11
2	3.210	2 602	81 06
3	4.701	3.976	84.58
4	6.247	5.337	85 43
5	7.704	6.550	85.02

In the last column are the corresponding efficiencies which are obtained by dividing the values in column 3 by those in column 2; that is, by dividing the inputs into the outputs. The values so obtained are multiplied by 100 to convert them into per cent.

Having the efficiencies corresponding to various outputs, we are in a position to construct the efficiency curve. Taking a piece of graph paper, lay off upon it a horizontal scale representing horsepower, from the zero point of which start a vertical scale representing efficiency in per cent. Then we locate the value of the horsepower output for each reading on the horizontal scale and similarly the value of each efficiency on the vertical scale. Thus, in Fig. 3 *a* is pointed off at 1.067 hp., *b* at 2.602 hp., etc.; likewise *f* is pointed off at 66.11 per cent., *g* at 81.06 per cent., and so on. Then an imaginary line is traced upward from *a* until it meets an imaginary line traced horizontally from *f*, their intersection at *k* being one point of the curve. In the same manner *l* is the intersection of *b* and *g*, *m* of *c* and *h*, etc. Having located the points *k*, *l*, *m*, *n* and *p*, the curve is drawn through them.

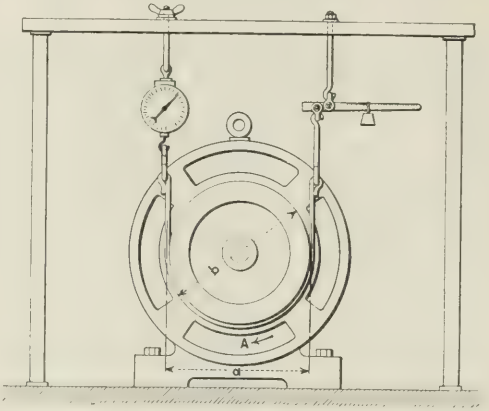


FIG. 4. BRAKE USING TWO SCALES

When the form of brake used is one using two scales, such as that shown in Fig. 4, the method of testing remains the same with the exception that two scales must be read for each load and that the diameter of the pulley is measured instead of the length of brake arm. Attention is to be called to the fact that the actual effective diameter is really the distance from center to center of belt as shown by *a*, and not the diameter of the pulley itself. The most convenient way to determine this effective diameter is to measure the distance from the pulley face to the outside of the belt on the opposite side, as indicated by *b*. The power output for each load would then be equal to $\pi \times D \times S \times (W_1 - W_2)$ in which D represents the effective diameter in feet, S the speed in r.p.m. and W_1 and

W_2 the pulls in pounds registered by the beam scale and the spring balance respectively. It is understood that the direction of rotation would have to be as indicated by the arrow A.

The problem of the preceding lesson dealt with a prony-brake test such as that illustrated in Fig. 1. It was stated that when the force acting on the scale platform is 17 lb. the speed of the motor is 1500 r.p.m., and it was required to find what horsepower the machine is delivering under these conditions if the length of the arm is 20 in. In the solution of this problem we can use the formula applied in the present lesson to the assumed brake test; namely, Output in hp. = $\frac{2 \times \pi \times S \times f \times l}{33{,}000}$. This will give us, Output in

$$\text{hp.} = \frac{2 \times 3.142 \times 1500 \times 17 \times 20}{33{,}000 \times 12} = 8.09.$$

Upon testing a motor by means of a brake such as that illustrated in Fig. 4, readings were obtained as given in Table III.

TABLE III. DATA OBTAINED FROM MOTOR UNDER TEST

Reading No.	E Volts	I Amperes	S R.p.m.	W_1 Lb. Oz.	W_2 Lb. Oz.
1	110	12.5	1200	24-06	10-05
2	110	25.0	1150	58-15	19-12
3	110	37.5	1100	92-11	27-07
4	110	50.0	1050	117-14	35-14
5	110	62.5	1000	162-15	43-10

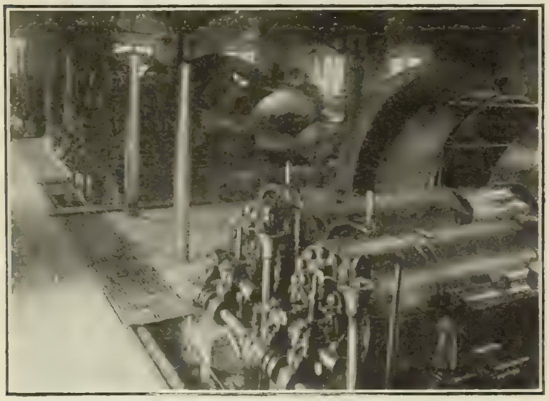
The effective pulley diameter is 8¼ in. Construct the efficiency curve of the motor.

Pumping Oil Wells by Electricity

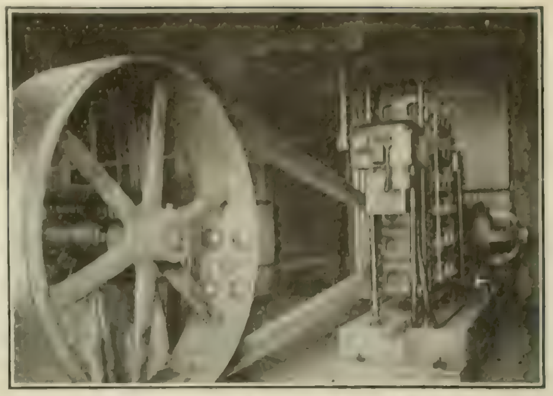
By O. H. Nonnenbruch

Steam power is still universally used for cable drilling of oil wells. Efforts to introduce more efficient prime movers have been made, but a change has not been brought about. After oil has been struck, it is usually necessary to pump the well to obtain the oil; this requires a comparatively small prime mover. Occasionally it is necessary, in order to inspect or repair the pumping equipment, to pull up the rods and tubing. In this case additional power is needed.

In the earlier days the steam engine and boiler that furnished the power for drilling the well were also used for pumping. This is a very wasteful method and results in an average fuel consumption of about ten barrels in twenty-four hours, an extremely high consumption for an output of less than ten horsepower. Subsequently, it became common practice to remove the steam engine and substitute a gas or oil engine after the well had begun to produce. This method resulted in a considerable reduction in fuel consumption, but still has its disadvantages, as the gas or oil engines distributed over a wide area require much attention. Besides this the fuel consumption is still comparatively high, because power units are small and not of a type that allows the best economy.



VIEW OF ENGINE ROOM



INSIDE THE MOTOR HOUSE

The latest method of production is to install at each well an electric motor. This permits centralization in the production of the current and offers possibilities for the highest economy, and the amount of attention required at the wells is reduced to a minimum. The power for operating the electric motors may be carried to the lease and from there to the various motors over transmission lines, or it may be developed in a central power plant located on the field. A typical example of this method is found on the Page-Lewis lease, near El Dorado, Kan., which is operated by the Magnolia Petroleum Co. The power plant contains four De La Vergne twin-cylinder Diesel engines, rated 360 hp. per unit. Each engine is belted to a 300-kv.-a. alternating-current generator, delivering current to the busbars at 2300 volts. The generators all operate in parallel on a 60-cycle three-phase circuit, and the current is transmitted to transformers located centrally with respect to each six wells, where it is stepped down to 440 volts. When operating the pumps, the motors develop up to 15 hp. at 550 r.p.m., and when used for pulling rods and tubing they are capable of developing up to 30 hp. at 1100 r.p.m. A pole-changing switch connects the different windings. The motors are reversible and equipped with controllers for speed regulation. They are belted to jackshafts and from there to the band wheels, which in turn operate the walking beams through pitman or wooden connecting-rods.

At present about 50 wells are operated from the central power house. The total fuel consumption is less than fourteen barrels of oil per twenty-four hours. This covers pumping, rod and tubing pulling for all the wells, electric lighting of the lease and power for a machine shop, as well as pumping of crude oil to pipe lines within the lease.

During the blizzard in January, 1919, when the Kansas fields were covered with snow and the temperature was below zero for several days, the electrically driven wells continued to operate without a shutdown or special attention. In neighboring fields gas-engine operated wells had to shut down for over a week owing to frozen gas pipes, etc., while others were kept going only by continuous and extraordinary efforts.

EDITORIALS

Why Does the Water in a Boiler Lift When the Safety Valve Blows?

THE Boiler Code Committee of the American Society of Mechanical Engineers recently gave a hearing to a delegation of manufacturers of safety valves. The 1914 edition of the Code limited the lift of a safety valve to fifteen one-hundredths of an inch irrespective of its diameter, and also limited the size to four and a half inches. Both of these restrictions have been removed in the latest edition of the Code, and the manufacturers came to remonstrate and to talk it over. One of the principal arguments presented against high lifts and large diameters was the lifting of the water said to occur with the sudden opening of a large aperture. A visualization of just what does occur under such circumstances would be helpful in determining to what extent such restrictions are advisable and how they should be applied.

What lifts the water from the level of the water line and throws it out of the safety valve?

When the valve opens, the steam rushes out at a rate proportionate to its absolute pressure. In order that there may be a flow of steam from the other parts of the boiler rapid enough to replace that which passes out of the safety valve, there must be a diminution of pressure in the area immediately below the valve. How great this difference in pressure must be depends upon the velocity with which the steam rushes toward the safety-valve opening, and this depends upon the shape and cross-sectional area of the steam space.

When the boiler is steaming, there is no definite water level. The surface is tossing and heaving with the disengagement of steam bubbles. This disengagement will be very active for the first instant that the pressure upon the surface of boiling water is reduced, and may be so active right under the valve as to throw up a column of water which, aided by the sweeping action of the steam rushing to the opening with the velocity of a cyclone, is carried out of the boiler. Knowledge of how waterspouts are formed and the conditions essential to their production and maintenance would be useful in this connection. Tales of cases in which the water continued to be discharged until the boiler was emptied are probably "grossly exaggerated."

The lifting action can be avoided by a gradual opening of the valve. "Gradual" is used in a comparative sense, for a valve may even *pop* more or less abruptly, and there may be a material difference in the behavior of a mass of water if the large opening is made all at once, liberating steam instantly and generously, or if the opening comes a little more gradually and allows of the less tempestuous release of the excess heat at the lowered pressure. It is for this reason that the A.S.M.E. Code says that "safety valves may be used which give any opening up to the full discharged capacity of the area of the opening at the base of the valve, provided the movement of the valve is gradual so as not to induce lifting of water in the boiler."

From this point of view and as far as lifting of the water is concerned, it appears to be a question more of timing operation than of lift. A certain safety-valve area is required to discharge the maximum amount of steam that a boiler can make. This area may be had with a valve of small lift and large diameter or one of large lift and correspondingly smaller diameter. The smaller valve with its lesser edge opening does not necessarily give the more sudden release.

Who knows what happens in a boiler when the safety valve lifts? We suggest it as a subject for thought, study and discussion. Our correspondence columns are open for contributions concerning it.

The Importance of Checking Electrical Instruments

CAREFUL checking and inspection of electrical instruments rarely receives the attention and consideration its importance warrants. The operation and control of electric machinery and apparatus is largely automatic. The functioning is shown by the indications of switchboard or other types of instruments. It is from the indications of electrical measuring instruments that loads are served, machines started and stopped—in fact, by which everything having to do with the safety of apparatus and its performance are judged. Yet these important, vital pieces of apparatus do not usually receive nearly the care they should.

The importance of careful synchronizing was emphasized by Mr. Gillooly in the April 29 issue. He told of what had happened when mistakes in synchronizing, due to faulty synchronoscopes, or otherwise had occurred. The trouble is that too few station attendants inspect their instruments often or carefully enough—letting well enough alone apparently.

That operating difficulties, damage to apparatus and derangement to service may occur when a synchronoscope is defective or functions wrongly is fairly obvious. So also when a voltmeter gives a wrong indication. However, some instruments might appear to play a less important part in safeguarding service and machines, as for instance the power-factor meter. This instrument has nothing to do with synchronizing or paralleling machines. It plays no part in the load distribution between alternating current machines, since the load distribution is a matter of energy input to the prime movers, which may be controlled by the governor's action. However, power-factor does depend upon terminal voltage, and therefore determines the wattless or magnetizing current that circulates between units connected in parallel. This circulating current does no useful work, but only reduces the capacity of equipment. Operating troubles caused by an inoperative power-factor meter, given by W. H. DeMuth, on page 985 of this issue emphasizes the importance of checking up instrument performance regularly and of the operator being at all times thoroughly familiar with his switchboard instruments.

The Electrical Study Course

FOR two and one-half years "The Electrical Study Course" has been published in *Power*. During this period the seventy-four lessons given have treated of direct-current apparatus almost exclusively, and if the contents of numerous letters sent in commenting on the course are any indication, it has filled a long-felt need. Beginning with the issue of July first and continuing for the rest of the year, alternating current and alternating-current apparatus will be given consideration. As has been done with the direct-current lessons, every effort will be made to present the coming lessons so that they can be easily understood by those with a limited knowledge of mathematics, electricity and magnetism.

The importance of the study of alternating current cannot be overemphasized, especially at this time, when its use is increasing so rapidly for most every conceivable purpose except electrolytic work, and even here in many cases the power is transmitted to where it is to be used as alternating current. Applications that until recently could be satisfactorily met only by the use of direct current are now being successfully done with alternating current, and the end is not yet. Therefore it behooves every operating engineer and electrician to familiarize himself with the fundamental principles of alternating-current apparatus, whether he has such machinery in charge at the present time or not, for the prospects are he may have at some future time.

The idea is all too prevalent that the subject of alternating current is difficult and complicated and can be understood only by highly trained technical men. This may be true of certain branches of the study, but it certainly cannot be said in regard to alternating-current power equipment, for in almost every case it is more simple in its construction than direct-current apparatus, and its operation can be understood easily by anyone who can understand the operation of direct-current apparatus. Anyone who can understand the operation of a direct-current generator can easily understand the operation of an alternator, since the direct-current machine is nothing more nor less than an alternating-current machine with the added complication of a commutator. If the readers of *Power* who are not familiar with the subject of alternating current will just forget that it is complicated and give conscientious study to the lessons that will appear during the next six months, they will find that the awe-inspiring features of the study were mostly imagination.

Articles on Refrigeration

WHEN the prohibition scare first hit some of the beer and liquor industries many years ago, builders of refrigerating machinery wondered how long it would be before the closing of breweries would also close their shops because of lack of business. Today prohibition is here, and the closing of breweries causes but a ripple on the growing sea of refrigerating business. Such is the growth of the industry. And the application of refrigeration to the industrial arts has but begun despite its varied use.

Refrigerating engineers who design and remodel plants can tell of almost unbelievable operating conditions found in refrigerating plants, large and small. These conditions are not confined to any particular section of the country; they are found all over the continent. And why? Well, the causes are numerous, but one of the chief reasons is inexperienced operating refrigerating engineers, many if not most of whom are not to be too severely criticized for their lack of knowledge and skill in refrigeration.

In the first place most owners of refrigerating plants, in putting men in charge of their equipment, seem to regard the question of whether these men are refrigerating engineers as secondary. There are not many thoroughly competent operating engineers in the refrigerating industry, and unless a man has been fortunate enough to work with one or more of these few, his training is likely to have been deficient. If so, he turns in vain for books that tell him and show him the how of things he needs to understand. A useful book for the operating refrigerating engineer never has been put on the market and likely never has been written.

The operators themselves must write for their fellow operators. The man with experience, the man who knows the principles of operation, who knows when equipment is inadequate for load demands, who can diagnose trouble and correct it, who can "make it go" in the face of adverse circumstance and when others fail, who can produce a ton of refrigeration or of ice with the highest practicable efficiency and at the lowest cost—this man is the fellow to whom his brother engineers must look for guidance, opinions and advice. It is to him that owners and builders must turn if their machines are to be well operated.

This is the man we are looking for. We have several whose articles are a boon to men in the field. We want more of the same kind—men who can tell "how to do it," not preachers of sermons.

If you are one of these, or if you think you are, if you feel that you have something of interest and value to say to others, let us have it. It is what you say that counts; not how you say it. We take care of the how. And it pays well, too—sentimentally and substantially.

Every steam engineer has his difficulties in power-plant operation, but judging from the pay some receive in comparison with the remuneration of other skilled employees, it would seem that the managements consider his position something akin to the everyday office boy; that he is a necessary evil of not much account, but something that cannot very well be eliminated.

The perpetual-motion crank is the Bolshevist of the mechanical world, for he firmly believes that he can produce unlimited comforts and necessities without personal exertion.

It is dangerous to stand on the arch of a dutch-oven furnace. It may fail under the weight and result in the workmen falling into the flames.

Many boilers have been made to give better evaporative results by changing the baffling. Have you tried it?

When men are working in an empty boiler, it is a good idea to lock all valves closed connecting to it.

A clean water glass is necessary to safety.

Correspondence

Inoperative Power-Factor Meter Caused Shutdown

In the Apr. 29 issue of *Power* Frank J. Gillooly, in an article entitled, "Don't Take Chances With the Synchronoscope," drew attention to the importance of being careful in synchronizing and checking up the synchronoscope. However, the synchronism indicator is not the only instrument that may cause trouble in the operation of electrical machinery; the fact of the matter is that most any of the switchboard instruments may do so under certain conditions—even the power-factor meter, as will be seen from the following:

A 2000-kw. frequency changer was used for transferring energy from a 60-cycle to a 25-cycle system and vice versa. A 1000-kw. set was also operated in the same station. The smaller frequency changer was operating and an increased load upon the 60-cycle system made it necessary to parallel the 2000-kw. unit, running the two units together upon a common busbar. The station attendant paralleled the machines and then began to adjust the field excitation of the synchronous motor on the 25-cycle end and of the generator on the 60-cycle end so as to bring the power factors up to normal.

The power factors of the synchronous motors were usually maintained around unity or 98 per cent. leading, to help out the system, whereas the power factors of the 60-cycle generators depended upon the power factor of the load and the excitation of the individual machines. At the time of paralleling the station load was heavy and the attendant tried to adjust the motor's power-factor of the large frequency-changer for unity. After the adjustment of the motor's and generator's field had gone on for some time, with the 60-cycle load rapidly increasing, the attendant discovered that he was unable to make the 1000-kw. generator pick up its proper share of the load, or bring the power factor of the 2000-kw. machine up to the same value as that of the smaller machine. In fact, he found that all adjustments of the field rheostats of all the machines had made no effect whatsoever upon the power factor of the 2000-kw. generator.

He thought that perhaps he had paralleled the two motor-generator sets wrongly, so that proper load division was impossible, but realized that the load was too heavy to cut out the smaller machine with a view to synchronizing them again. Just about this time the 25-cycle oil switch controlling the 2000-kw. synchronous motor of the large frequency-changer set opened, shutting down this machine. The 2000-kw. load was immediately picked up by the 1000-kw. machine in addition to its own load, and this unit shut down, causing a complete interruption of service.

The whole trouble was caused by the power-factor meter of the 2000-kw. 60-cycle generator not working, because the fuse in the transformer supplying it had blown. From the time this set was started to the time it shut itself down, the power-factor meter's pointer had not moved. The shutdown was caused by the excessive overload on the motor, necessitated by the overexcitation of its field in the endeavor of the operator to maintain normal power factor when the meter was not working. If the operator had had a proper understanding of his equipment, he would have noticed very soon that the power-factor meter was not responding to rheostat adjustment and found that the load distribution was not normal. The doctrine of checking instruments should be preached often and loud.

Chicago, Ill. W. H. DEMUTH.

Why a Centrifugal Pump Failed To Feed Boilers

I had an experience with a pair of three-stage centrifugal boiler-feed pumps, which may be of interest and help. Each pump had a capacity of 1000 gal. per min. and was steam-driven and connected in parallel between the supply main from the open heaters and the boiler-feed water line, with a gate valve in both suction and discharge and a check valve in the discharge line of each pump. The pumps furnished feed water to water-tube boilers of about 6000 hp. capacity working on a 24-hour service operating alternately one week at a time.

Every Saturday afternoon one pump is shut down, the bearings, governor and pressure regulator inspected and cleaned, and then left with suction and discharge valves open ready to be started at a minute's notice.

On this particular day No. 1 pump was started and appeared to be operating all right, but as soon as the throttle was closed on No. 2 pump the pressure began to drop and No. 2 had to be put in service again to keep the water in the boilers.

The governor and pressure regulator were carefully inspected and another trial gave no better results. As the pump had operated satisfactorily when it was shut down the previous week and had not been started in the meantime, we could see no reason why it should not pump. The chief was called, and after witnessing a trial and testing the speed, he ordered the machine dismantled and a thorough inspection made of the impellers, diffusers and shaft bushings. After everything was found to be all right and another trial made, he had the suction and discharge pipes removed and examined for obstructions. Everything was found in proper condition, but still the pump would not feed the boilers.

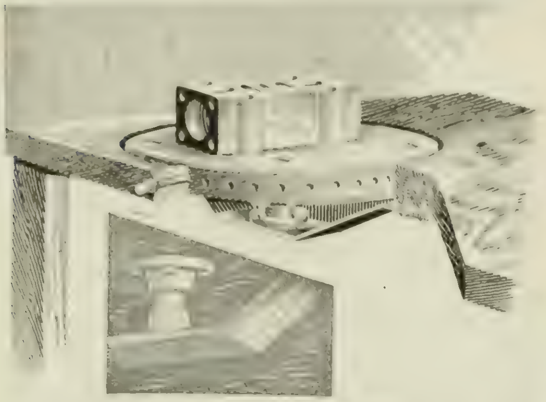
It was then about 8 p.m. Sunday, and the men were at the end of their rope. Since the load was very light at this time, No. 2 pump was stopped to see if No. 1 would pick up the pressure after a few minutes; but instead of stopping, No. 2 pump started to run back after the throttle was closed.

This showed conclusively that the discharge check valve on No. 2 was the cause of all the trouble, for as soon as its speed dropped sufficiently, No. 1 pump had bypassed its water through the other and thus could not keep up the pressure. ERNEST K. MANNING.

Watertown, Conn.

Workbench Turntable

A simple but useful device that I have adopted for handling heavy castings or machinery parts while doing bench work is a revolving table set in the bench flush with the top. It is easily made from two large-sized pipe flanges, a nipple and a couple of suitable hangers made of ½ x 1 in. flat stock.


REVOLVING BENCH TABLE

The top of the turntable plank is covered with a piece of ⅛- or ¼-in. plate steel. The idea is conveyed in the accompanying sketches. A locking pin is used to hold the table in any desired position.

Concord, N. H. **C. H. Willey.**

Feed-Water Check-Valve Failure

In the May 6 issue of *Power*, page 698, R. J. Fox, in explaining the cause of a boiler being burnt, makes some statements with which I do not agree. For instance, he states that an automatic stop valve closed and cut a leaking boiler off the line, and further, that the faster the fireman ran his pump the faster the water fell in the gage-glass, and that the water rose in the other boilers owing to the siphoning action from the damaged one.

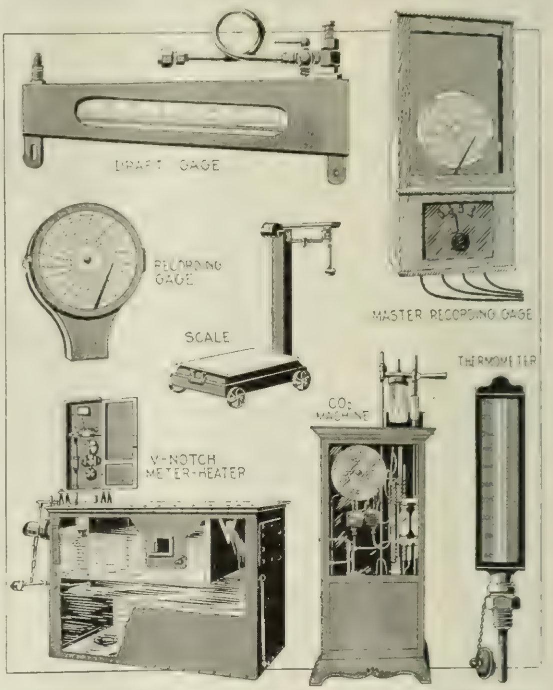
When the automatic valve closed on the damaged boiler, it showed that the pressure on that boiler had been reduced below that of the other boilers on the line. Therefore there could be no siphoning of water from the boiler with lower pressure to those of higher pressure. According to my way of reasoning the action would be just the reverse. As the water would take the path of the least resistance, it would naturally flow to the boiler with the lower pressure, and the automatic valve closing on the damaged boiler proves that the pressure was reduced. There could be no such thing as the water siphoning from the lower pressure to the higher pressure on the other boilers on that line. I would like to have others express opinions regarding that burnt boiler. **M. H. Harrington.**

Fall River, Mass.

Economical Operation of Boiler Plants

The United States Fuel Administration during its operation insisted that every boiler plant in the country be operated with the utmost economy as regards fuel and oil consumption; further that suitable apparatus be installed to make possible and attainable economic operation. Without doubt the majority of boiler plants throughout the land complied with the suggestions of the Fuel Administration, and a world of good was accomplished, also many thousand tons of coal was saved. In view of these results it is surprising that when the Government builds boiler plants no attention is paid to the economic operation and generally no apparatus is installed to enable the engineer in charge to control his plant economically.

During the last few months I have had opportunity for personal observations along these lines. One of the many cases observed is that of a permanent hospital which has been built for the army, in which high-grade water-tube boilers with chain-grate stokers have been installed. The capacity of the present installation is 1600 hp. with room for 800 hp. additional. These boilers operate under a pressure of about 100 lb. and are used for generating steam for heating the buildings and also for cooking in the various kitchens. In short the plant is up-to-date in every particular except that there are no provisions made for the determination of draft, flue-gas composition, amount and temperature of feed water; nor are there recording pressure gages. There is not even a pair of platform scales to weigh the coal used. Several requests have been made for the purchase and installation of the apparatus needed, but these requests have been turned down or ignored. From this it is readily seen that no one could operate the plant economically. This plant is under the supervision of a regular army man who is blissfully ignorant of the proper operation of boilers and their accessories.



SOME OF THE INSTRUMENTS THAT WERE MISSING

Several other similar incidents might be cited; but why go further? The fact remains that it seems quite proper for the Government-owned plants to be operated as efficiently as present-day science can make them, yet one runs against this state of affairs constantly in Government work. **A. F. Lawler.**

Denver, Col.

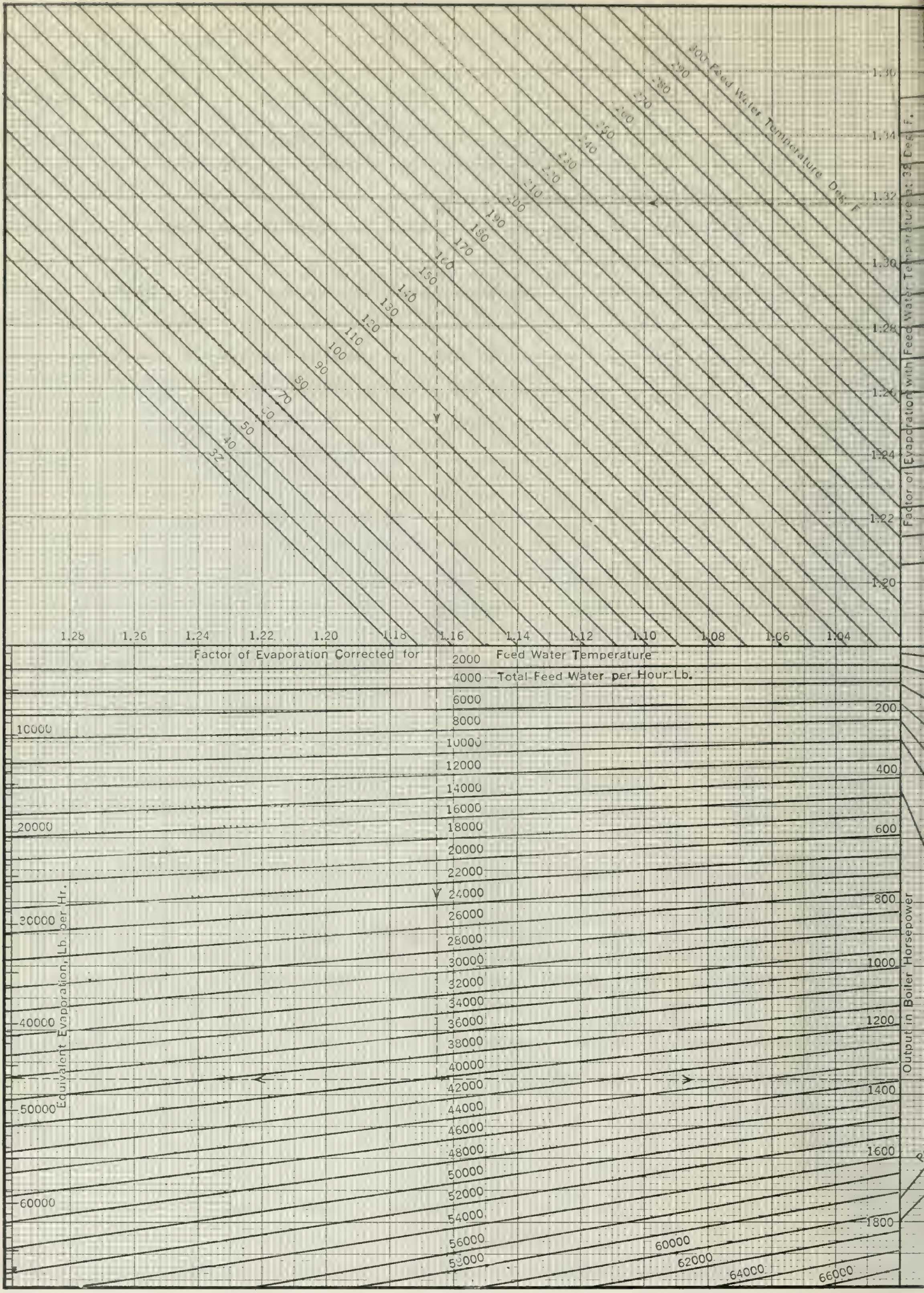
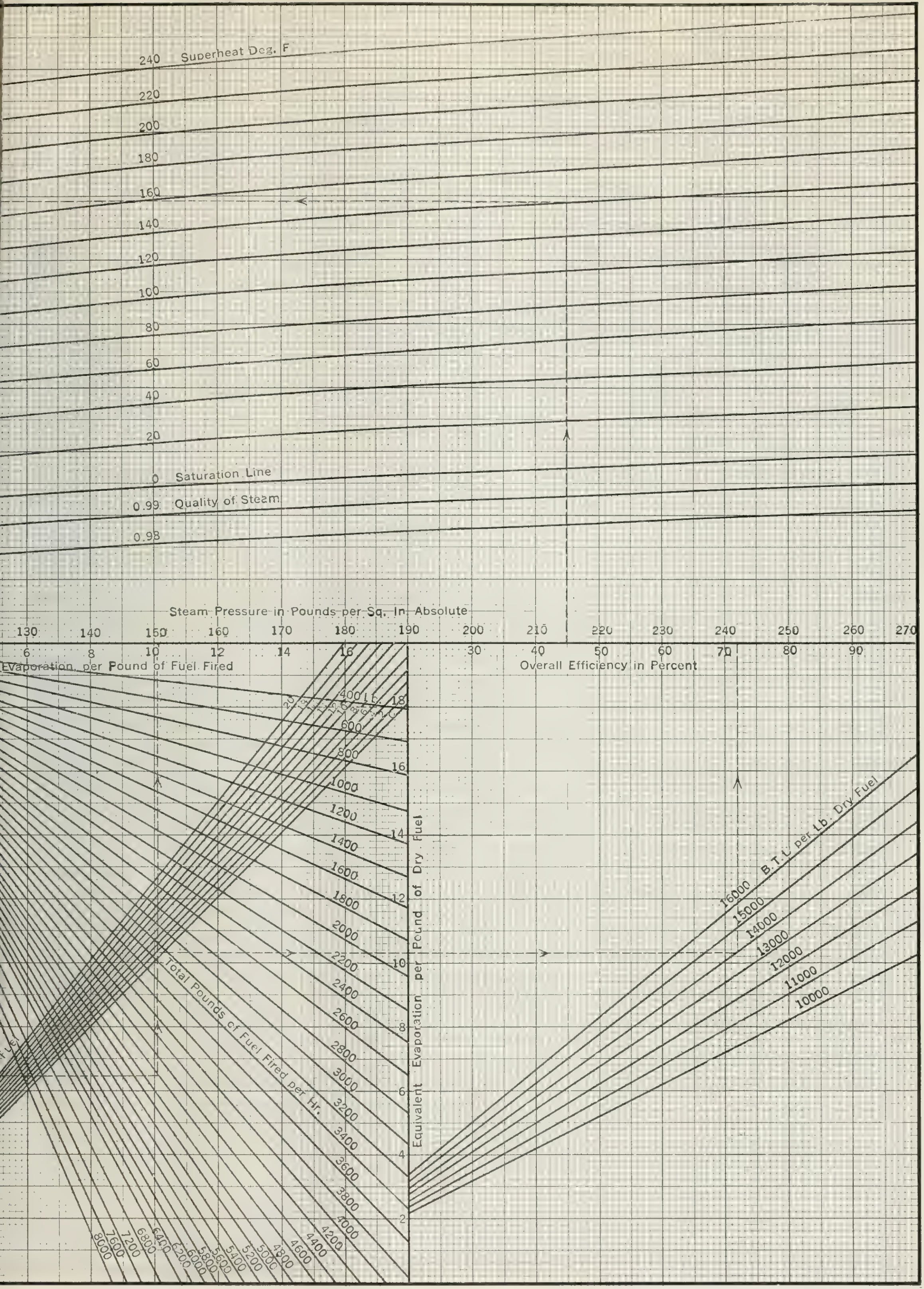


Chart for Finding Factor of Evaporation, Equivalent Evaporation, Evaporation



Supplement to Power, June 24, 1919

ound of Coal and Boiler Efficiency, Based on the Marks and Davis Steam Tables

Use the Broken Firebrick

It seems to me that it would pay some manufacturer of crushers and grinders to bring out a portable combined crusher and grinder with a mixer similar to a concrete mixer, to grind up firebrick, which is usually thrown away when making repairs to boiler brickwork.

Ground firebrick mixed with just enough fireclay to form a binder, together with a small amount of asbestos, makes an excellent cement for patching baffles, arches, door arches and side walls. I have used the mixture for these purposes to good advantage, and to say it saved my employers considerable in brickwork maintenance would be putting it mildly.

The mixture is as follows: Ground firebrick, 4 parts; fireclay, 1 part; asbestos, 1 part. It is mixed with a saturated solution of salt water. The firebrick should not be ground too fine. The less fireclay and asbestos used the longer the work will stand, and it is better adapted to withstand high temperatures. The mixture should be mixed one day and used the next; in other words, it should be mixed at least twelve hours before it is used.

Broken pipe covering and lagging can be utilized in this way. The asbestos makes the compound more ductile or workable, and it will stay put better. The mixture should not be too wet, but just moist enough to amalgamate with another body.

Many medium-sized and large plants could save thousands of dollars annually in the cost of labor and firebrick for repairs or alterations to boiler furnaces if such a mixture were available. Savings also result from its use for temporary repairs, as it frequently happens that firebrick linings give way unexpectedly in spots. As continued operation would ruin the common brick wall, it is necessary to take the boiler off. If brickmasons are called it may take two or three days to make the necessary repairs, whereas if the mixture is used the boiler can be in on the line in twelve hours' time, permanent repairs being deferred until a more opportune time. WALDO WEAVER.

Franklin, Ohio.

Synchronous Motor Would Not Start

The electrical equipment of a large mill included several synchronous motors, one of which had been so badly damaged by fire and water that rewinding was necessary. A complete set of coils was available and the rewinding was done by local repairmen. After completing the job, however, connecting the motor to its source of power failed to turn the rotor, although it had started very promptly before being damaged. Higher compensator taps were tried, but to no avail. An expert alternator winder was called from the factory and found that one pole-phase group of coils had been reversed as at *X*, Fig. 1. The interchanging of the leads of this group, as in Fig. 2, restored normal starting torque. It will be noticed that by tracing each phase through to the star connection in Fig. 2, the arrows point in opposite directions on adjacent pole-phase groups, which is the correct condition. In Fig. 1 the wrong connection is indicated by three adjacent arrows pointing in the same direction.

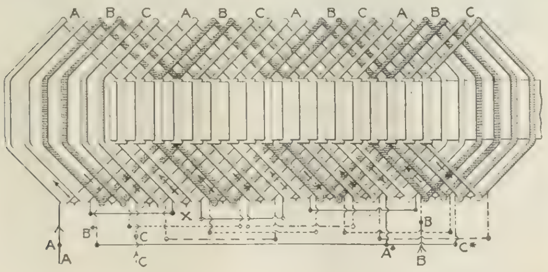


FIG. 1. POLE-PHASE GROUP SHOWN REVERSED AT X

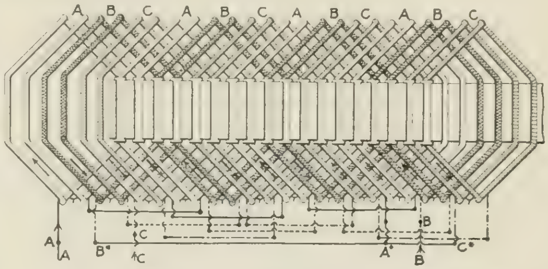


FIG. 2. CORRECT CONNECTION FOR A FOUR-POLE SERIES-STAR WINDING

The existence of such a condition may be proved by connecting ammeters into each phase conductor and observing the intake currents while the rotor is turned by hand; a reversed pole-phase group of coils will greatly unbalance the currents of the three wires. It is essential that the rotor be rotated so as to equalize impedance differences due to different phases including different amounts of iron in their magnetic circuits.

Brooklyn, N. Y. E. C. PARHAM.

Trouble With Scored Fuel-Valve Seat

The condition described by D. L. Fagnan in *Power* of Apr. 15 exists in too many Diesel plants. One is quite safe in stating that 25 per cent. of Diesel installations are troubled with leaky fuel valves. This condition, if allowed to exist, is blameable on the operating engineer.

Mr. Fagnan's method of detecting a scored fuel-valve seat is one that cannot be used in all cases. In many instances a valve will leak the high-pressure air when the groove that is causing the trouble can hardly be detected with the eye after the valve seat is removed. It is apparent that in such cases these minute grooves will not show on a wooden stick, no matter how highly polished the stick may be. Furthermore, most of the leaks are due to the minute pits that form on the narrow ground seat, this being seldom more than $\frac{1}{64}$ in. in width. These pits are below the general surface of the seat, and in no case will they show with the "stick-method."

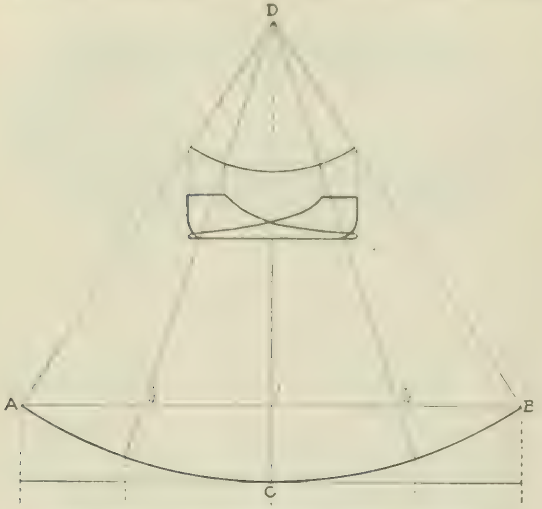
To detect a leaky fuel valve the injection air should be turned on and either the suction or the exhaust valve and cage removed. By reaching through this opening and placing the hand against the atomizer or fuel tip disk, the air will be felt blowing through the fuel valve. Then if the valve continues to leak after the needle valve has been reground, it is evident that the valve seat is in bad shape and should be reamed.

In doing the reaming if extreme care is not used the reamer will cause chatter marks, which, of course, will make conditions worse. E. E. SNOW.

Philadelphia, Penn.

Altering a Reducing Motion

After reading the letter on page 539 of the Apr. 8 issue of *Power*, by M. J. Merrell, concerning altering a reducing motion, I wonder if it has occurred to him that it is impossible to get a correct card with that kind of a reducing motion because, as the crosshead moves from one end toward half stroke, the pin finds a higher position in the slotted end of the lever; or, in other words, it pushes on a shorter lever at midstroke than it does at the ends of the stroke. This causes the diagram to stretch some in the middle and to bunch nearer the ends. Of course, figures obtained from such an incorrect diagram are also incorrect.



SHOWING DIFFERENCE IN LEVER LENGTH

The accompanying sketch clearly shows this condition, and a little study and thought should convince anyone that this kind of reducer should not be used if accurate figures are expected. The straight line AB represents the crosshead travel, which is divided into four equal parts representing quarter stroke, half stroke, etc. The radii passing through these points from the pivot point D represent the pendulum at these points of the stroke. It will be noticed that at half stroke the arc, or curved line, $A\ C\ B$, which is the line of travel of the point of contact with the crosshead pin at the ends of the stroke, is quite a distance below the straight line, showing a much shorter lever transmitting the motion at this point than at quarter stroke and at the ends of the stroke. The insert diagram shows that the distance from one end to the quarter stroke is shorter than from the quarter to half stroke. The perpendicular dotted lines at the bottom show these same points on a larger scale. **Frank Avis.**

Verde, Ariz.

Live Versus Exhaust Steam for Heating

I have read many articles on the subject of live versus exhaust steam for heating purposes, and a large percentage of the writers claim that no more or even less coal is burned with engines running and carrying a load and using the exhaust steam for heating than with the engines stopped and using live steam.

I cannot dispute this statement, neither can I deny that others are getting the results they claim. In the plant of which I have charge direct-connected steam engines are used. The exhaust steam passes through the boiler feed-water heater, the surplus going into the heating mains in the winter and through a domestic water heater during the summer months.

On dark or cloudy winter days the engines are run so that the lamps can be used by day as well as by night. On clear days the engines are shut down during the bright hours and a reducing valve allows live steam to enter the heating mains.

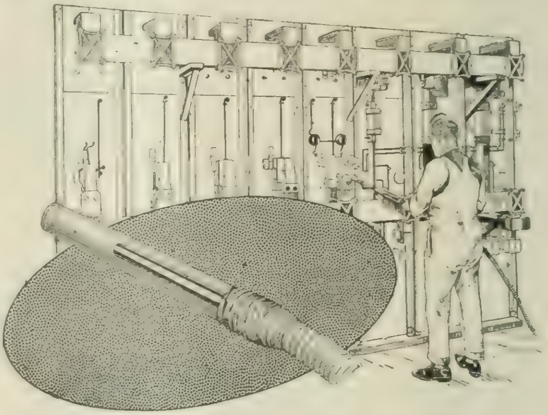
Our 24-hour consumption of boiler water in the winter is from 300,000 to 400,000 lb., and the pressure on the heating system seldom reaches and never exceeds 5 lb. gage. On days when engines are used for the full 24 hours the coal consumption for the hours the engines are running is from 5 to 10 per cent. greater than when they are idle. All exhaust steam and practically all condensate from the water heaters and other fixtures throughout the plant are used both in summer and in winter.

There is no blowing of one into the atmosphere and of the other to the sewer as is sometimes done. I fail to burn less coal with the engines working than when they are idle. I am open to conviction, however, and would be delighted to learn why I am using more fuel with my engines running, while others are using less.

Kingston, Ont., Canada. **James E. Noble.**

Safe Switchboard Blower

It is risky to blow down the back of a switchboard with an air hose and the usual metal nozzle, for no matter how careful the attendant may be contact is likely to be made with a live connection, especially when busses run along the back of the board. By placing a piece of water-gage glass over the nozzle as far as it will go, as shown in the insert illustration, and having the end of the glass tube beyond the end of the nozzle about two inches, the danger is eliminated.



SWITCHBOARD BLOWER AND ITS APPLICATION

The glass is secured to the hose by wrapping with adhesive tape. **W. H. Watson.**

Norristown, Penn.

A liquid metal polish for cold smooth surfaces, either iron or brass, can be made by adding 2 oz. of oxalic acid and 1½ lb. of silicate powder to 3 parts of benzine. Keep in a bottle tightly corked and shake well before using.

Inquiries of General Interest

Heating Surface for Feed Water Heater—How many square feet of heating surface should there be in a closed exhaust-steam feed-water heater, receiving the exhaust of a 13 x 14-in. engine that is used for driving a 75-kw. generator? J. H. G.

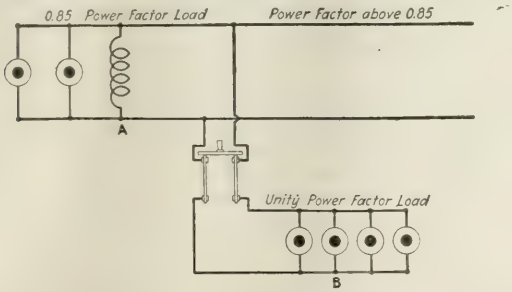
Allowing 90 per cent. efficiency of generator, 85 per cent. mechanical efficiency of the engine and 30 lb. of water per hp.-hour, development of 75 kw. would require about $75 \div (0.746 \times 0.9 \times 0.85) = 131$ boiler hp. For raising the temperature of the feed water from 60 deg. F. to about 204 deg. F., there should be not less than ½ sq. ft. of feed water heating surface per boiler hp., and for operation of the generator to full capacity, the heater should have not less than 65.5 sq. ft. of heating surface.

Determining Working Pressure of Boiler—How should the working pressure be determined for a boiler that has a crack in the shell? W. N.

A boiler that has a cracked shell should not be used until it has been repaired in a first-class manner. The working pressure suitable for the boiler should be decided upon from computation of the strength of all of its parts and should be limited to the maximum safe working pressure for any part of the whole construction, using factors of strength of materials and factors of safety appropriate to the condition, age and proposed use of the boiler. A hydrostatic pressure test should be applied that is 50 per cent. more than the proposed working pressure to determine whether the boiler is tight rather than to decide whether the proposed working pressure is a safe one, for that depends mainly on the accuracy of computations and good judgment that have been employed in fixing upon the safe working pressure.

Power Factor of Current Supply—In our plant power is purchased from a central-station company. We are penalized on a power factor of less than 80 per cent. What should be the power factor of the current furnished us? Suppose our average power factor for one month was 0.70 and the power factor of the current supplied us is 0.85, what would be our power factor if the incoming current had a power factor of 0.95? H. R. B.

The power factor of the supply circuit has nothing to do with the power factor of any load that may be connected to the source of supply. On the other hand, the power factor of the supply is the resultant power factor of all the loads supplied. If the power factor of the supply circuit was 0.85, as in the figure, and you were to connect a unity power factor load *B* to the system, the power factor of this part of the load would still be unity, but the power factor between where the load *B* is connected to the line and the generator will be improved; by how much will depend upon the relative sizes of the loads. Therefore the power factor of the power company's lines before your load is connected to it has nothing to do with what the power factor of your load will be, as that is determined by the kind of equipment you connect on the circuit.

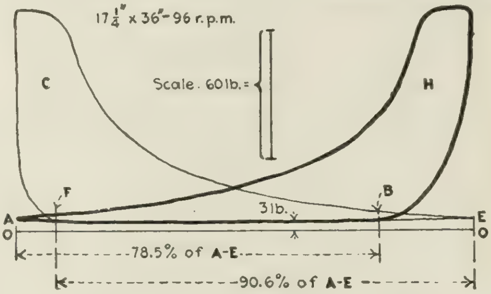


Changing Voltage of D.-C. Circuit—What is the most practical way of changing 500-volt direct current into 100-volt direct current? C. A. C.

The only practical way to convert direct current of one voltage into direct current of another voltage is to use a motor-generator set. In the problem in question a 500-volt motor would be used to drive a 110-volt generator.

Heating Value of Exhaust Shown by Indicator Diagrams—The accompanying indicator diagrams are from a 17¼ x 36-in. engine running 96 r.p.m., the exhaust of which is used for heating paper driers. What is the value of the exhaust expressed in boiler horsepower? G. W. E.

It is fair to assume that the exhaust steam delivered by the engine has the same heat value as an equal volume of dry saturated steam at the same pressure. The volume of steam discharged during each exhaust stroke will be equal to the piston displacement from the beginning of the return stroke to the point of stroke where the exhaust valve is closed, or the point usually referred to as the beginning of compression. In diagram *H* the beginning of the return stroke is represented at *A*, the point of closure of the exhaust is indicated at *B*, and as the distance *AB* is, by measurement, 78.5 per cent. of the length of the diagram, the volume of exhaust discharged from the *H* or head end of the cylinder is that same percentage of piston displacement for a complete return stroke represented by *AE*, the length of diagram. Similarly, for the *C* diagram, the distance *EF* represents 90.6 per cent. of the piston displacement of a return stroke in the crank end of the cylinder.



Neglecting the reduction of piston displacement in the crank end of the cylinder due to presence of the piston rod the displacement for a complete stroke of the piston would be $(17\frac{1}{4} \times 17\frac{1}{4} \times 0.7854 \times 36) \div 1728 = 4.87$ cu.ft. and in 96 r.p.m. for the fractions of strokes during which the piston pushes the exhaust from the cylinder, there will be delivery of $4.87 \times (0.785 + 0.906) \times 96 = 790.6$ cu. ft. of exhaust steam per minute at the pressure of about 3 lb. gage as indicated above atmospheric pressure line *OO*.

The density of steam at 3 lb. gage is 0.04512 lb. per cu. ft., so that the delivery would amount to $790.6 \times 0.04512 \times 60 = 2140.3$ lb. of steam per hour. The latent heat of steam at 3 lb. gage is 963.7 B.t.u. per pound and without crediting any recovery of heat from the condensate the exhaust would have a heating value of $2140.3 \times 963.7 = 2{,}062{,}607$ B.t.u. per hour. As one boiler horsepower is equivalent to 33,479 B.t.u. per hour, the exhaust would have a value of $2{,}062{,}607 \div 33{,}479 = 61.6$ boiler horsepower.

American Society of Heating and Ventilating Engineers

THE semi-annual meeting of the American Society of Heating and Ventilating Engineers held at Pittsburgh, Penn., Tuesday, Wednesday and Thursday, June 10, 11 and 12, with headquarters at the William Penn Hotel, was attended by over 150 members and guests. The meeting proved to be one of unusual interest on account of the opportunities afforded members and guests to inspect the laboratories of the Bureau of Mines, at which will be located the Research Bureau of the society. A special session was held in the auditorium of the Bureau of Mines Building, after which the admirable facilities afforded for research work in coöperation with the Bureau were witnessed with much gratification. Another notable feature of the convention was a joint session with the National District Heating Association, whose tenth annual convention was held at the William Penn Hotel during the same time. The joint professional session was devoted to the question of computing direct radiation for buildings and other subjects of leading interest to both associations.

Motoring, shopping and sight-seeing excursions were provided for the lady guests during business sessions of the association, and on Tuesday evening members and guests were entertained at the Carnegie Institute of Technology by a production of Shakespeare's "Twelfth Night" that was creditably presented by the School of Drama of the Institute. On Wednesday evening members and guests of both associations joined in an informal reception and dinner dance at the "Pines," and on Thursday afternoon they were entertained by a boat trip up the Monongahela River and visit of inspection to the McKeesport plant of the National Tube Co.

Business and Professional Sessions

The first session was taken up by the annual reports of the various chapters of the association and reports of committees on coöperation with United States Navy Department, and on Schoolhouse Standards; a paper on "Classroom Ventilation," by Konrad Meier, and "Heating and Ventilating the Standard Schoolhouse," by J. D. Cassell.

The Committee on Research announced that Prof. John R. Allen, who has been secured as director of the society's Bureau of Research, will assume active charge of the bureau on Aug. 1. Following the professional session held at the auditorium of the laboratories of the United States Bureau of Mines, the committee conducted members and guests on a tour of inspection of the splendidly equipped plant of the Bureau of Mines, which will be the headquarters of the Research Bureau.

The Bureau of Mines Plant

The main portion of the building is arranged for offices, auditoriums, meeting rooms, etc. One wing has been arranged for chemical research, where every facility and service required is supplied. The opposite wing is arranged for physical research. The first floor of this building is one long room, arranged with all service that could be expected to be used in physical research. A power house with ample capacity is in the rear of the building. The Fuel Research Laboratory is located in the power house and is provided with separate stack and arranged so that practically any fuel testing in actual practice under boilers or furnaces can be conducted.

The service consists of steam at high or low pressure; electric current, both direct and alternating; gas; hot and cold water; sewer connections, and compressed air. This service is available in practically any part of the plant.

Offices for the Bureau of Heating and Ventilating Research will be provided in the main building and are quite commodious and in every way suited for the work. The location of this building is of particular importance. Adjoining the Carnegie Institute of Technology, and within a block is the wonderful Carnegie Library. The University of Pittsburgh stands on the next hill, within plain sight and short walking distance. The Mellon Institute of Research is only a few blocks away. From this it may be seen that the atmosphere of scientific investigation and research and the assistance and coöperation that will be at hand is of the greatest value to this undertaking.

Co-operation with United States Bureau of Mines

The contract between the American Society of Heating and Ventilating Engineers and the Bureau of Mines is now being drawn to cover the activities of each in this coöperative work.

By this contract the society agrees to expend not less than $15,000 per year in this coöperative plan (it expects to spend at least $25,000). The society will furnish a director of research at a salary of $6000 a year; such assistants, investigators, engineers, stenographers, etc., as may be required and the funds available will permit; and the necessary instruments, appliances and apparatus for carrying on the work under investigation.

The Bureau of Mines is to furnish three investigators—one at a salary of $3000, one at $1800 and one at $1200. The Bureau of Mines will also furnish office space and janitor service, use of their physical and chemical research laboratories as space conditions may permit and the requirements may dictate; use of special laboratory in connection with the power house; service in the form of steam at high or low pressure; direct or alternating current; hot or cold water and gas, etc.; use of such instruments as they may have available.

It is needless to point out the value to the society accruing from this coöperation on the part of the Bureau of Mines. The bureau is anxious to coöperate in every way and the committee hopes and believes that such assistance may be mutually advantageous.

A report of progress in warm-air furnace research conducted by the engineering experiment station, University of Illinois, in coöperation with the National Warm-Air Heating and Ventilating Association contained in Bulletin No. 112 of the Experiment Station was presented by A. C. Willard, professor of heating and ventilation.

This is a preliminary report of progress under the present coöperative agreement between the National Warm-Air Heating and Ventilating Association and the University of Illinois for an investigation of warm-air furnaces and furnace heating systems.

The university through its engineering experiment station is to assume the responsibility of maintaining the necessary staff and conducting the investigation and, of course, it is further responsible for the reliability and unbiased character of all results obtained. Publication will be made from time to time in official bulletins of the station for the purpose of furnishing whatever scientific and technical data are developed in this work for the benefit of the engineering profession and the warm-air furnace industry.

The fundamental ideas involved in the methods used in this investigation, as well as the furnace plant itself and its essential features, were developed and put into operation by the Department of Mechanical Engineering of the University of Illinois in the spring of 1918.

Briefly stated, the principal objects of the investigation are:

1. To determine the efficiency and capacity of commercial warm-air furnaces under conditions similar to those existing in actual installations with leaders, stacks and registers to form a complete system.

2. To determine satisfactory and simple methods for rating furnaces so that the proper size and type of furnace can be definitely selected for the service required.

3. To determine methods of increasing the efficiency and capacity of furnace heating equipment and the advantages or desirability of certain types of design.

4. To determine the heat losses in furnace heating systems and the value of insulating materials as affecting the economy of the furnace or the leaders and stacks, and finally of the system as a whole.

5. To determine the proper sizes and proportions of leaders, stacks and registers supplying air to first, second and third floors.

6. To determine the friction losses in the cold air or recirculating ducts and registers and their proper size, proportions and arrangement or location.

7. Eventually, to make a study and comparison of outside and inside air circulation as affecting the economy and operation of furnace systems.

The report very completely illustrates and describes the instruments, apparatus and methods employed in the investigations.

A satisfactory method for measuring temperatures at many points had to be developed, and is accurate within one or two degrees.

The report recommends that for the maximum load conditions in practice the register temperatures should be taken as high as 175 to 185 deg. F., but for average conditions the register temperature should not exceed 150 deg. F.

In no case must the rate of combustion at any time require a draft in excess of 0.2 in. water gage.

The heat- and air-carrying capacities, and the heat losses of various kinds and sizes of leaders and stacks and other problems involving the length and pitch of leaders as well as the heights of and offsets in stacks are being solved by the tests now in progress.

A report of "Continuation of Work in Dust Determinations" was presented by Dr. E. Vernon Hill and Otto W. Armspach, and Monday morning's professional session was devoted to reading and discussion papers on "Utilization of Sprinkler System Piping for Heating," by A. W. Moulder; "Remodeling a Heating System," by Miss Helen R. Innis; and "Heating and Ventilating Systems at the United States Government's Smokeless Powder Plant, at Nitro, W. Va.," by G. W. Hubbard.

JOINT MEETING WITH NATIONAL DISTRICT HEATING ASSOCIATION

At a joint meeting with the National District Heating Association, the two associations discussed the report of the Rules and Regulations Committee of the National District Heating Association on Standard Rules for Computing Required Radiation, referred to in our account of the proceedings of the District Heating Association. The heating and ventilating engineers presented a paper on "Industrial Uses of Superheated Steam," by Alexander Bradley, and a paper on "Capacities of Reducing Valves for Steam Heating Systems," by James A. Donnelly as follows:

The capacities of reducing valves may be considered from two viewpoints. One, that they should not be greater than that of the inlet and outlet pipes to supply the steam and carry it away, with a reasonable or standard drop in pressure per unit of length, and that the area of the seats should be suitable for this rated capacity. The other viewpoint might be that the area of the seats should always be as large as the area of the inlet pipe and that the sizes of the supply and delivery pipes should be increased to correspond to the maximum capacity of the valve seats.

The latter method would often result in the use of a reducing valve and connecting nipples much smaller than the supply and delivery mains, and therefore much weaker structurally, from a mechanical standpoint. This would result in a design that is liable to rupture from expansion strains of the piping, and it may, therefore, be considered better engineering practice to rate the valves at the capacity of the inlet and outlet pipes and consider the necessary size of the seats for these ratings.

It is also desirable that the reducing valves and the sizes of the seats be so proportioned that the valves will have as large a lift as practicable in order that wiredrawing or cutting of the disks and seats may be avoided. This also results in a more accurate regulation, as smaller seats are easier to control.

Reducing valves for steam heating systems are usually made with the pipe size of the outlet double that of the inlet. They are usually provided with double seats of such a diameter that the combined area of the two is approximately equal to the area of the inlet pipe, although some have but a single seat, usually the diameter of the inlet pipe. The maximum movement of the disks is usually designed for one-quarter the diameter of the seats, thus giving full area of opening of the valve, but it is doubtful if a movement as great as this is obtained without considerable sacrifice of sensitiveness, and it will, therefore, probably be preferable to calculate their capacity on a maximum movement of one-eighth the disk diameter. This will also allow a reasonable factor of safety or possibility of overload sufficient for starting up a cold plant.

The velocity of flow of steam of a greater pressure into an atmosphere of a less pressure, increases as the difference of pressure is increased, until the delivery pressure becomes 58 per cent. of the initial pressure. The flow does not, thereafter, increase by a further decrease of the delivery pressure, and increases very slowly by a greater initial pressure, because the density and the weight to be removed increase with the pressure.

If the inlet pressure is but 25 lb. absolute, or 10 lb. gage pressure, and the outlet pressure atmospheric, the condition of 58 per cent. delivery pressure is present and the velocity of flow through a converging nozzle is 863 ft. per sec., resulting in a delivery of approximately 23 lb. per minute per sq.in. area of orifice. Tests by the author on fractional valves indicated that they had an efficiency of orifice of about 60 per cent. Applying this factor would indicate a delivery of about 14 lb. per sq.in. area of orifice per minute, or sufficient steam for the normal supply of 2800 sq.ft. of radiation with a reasonable allowance for the condensing effect of the piping system.

In the following table, the usual sizes of reducing valves are rated in accordance with the standard rating of steam mains, corresponding to the low-pressure side of the valve. These ratings divided by 2800 give the necessary areas through the valve seats for steam at 10 lb. gage pressure to be reduced to atmosphere.

RATINGS FOR THE USUAL SIZE OF REDUCING VALVES

Valve Size, In.	Rating	Seat Areas, Sq.In.	Diameter Double Seat, In.	Usual Diameter Double Seat, In.	Diameter Single Seat, In.
1 x 2	300	0.1	3/8	23/32	5/8
1¼ x 2½	500	0.18	1/2	7/8	11/16
1½ x 3	900	0.32	21/32	1 1/16	29/32
2 x 4	2,000	0.71	1	1 1/2	1 3/8
2½ x 5	3,600	1.29	1 5/16	1 3/4	1 13/16
3 x 6	6,000	2.14	1 11/16	2 1/8	2 3/8
4 x 8	13,000	4.64	2 7/16	2 7/8	3 7/16
5 x 10	23,000	8.21	3 1/4	3 1/2	4 9/16
6 x 12	37,000	13.2	4 1/8	4 1/4	5 1/4
8 x 16	78,000	27.9	6	5 3/4	8 3/8

The fourth column gives the required diameter for double seat valves, while the fifth column gives the diameter commonly used. The sixth column gives the required diameter for single seat valves.

It will be seen from this table that the areas of seats as commonly made are amply large even at the unusually low initial pressure of 10 lb. The necessary areas of seats as given above may be divided by 2 if the inlet pressure is increased to 35 lb. gage; by 3, if increased to 60 lb.; by 4, if increased to 85 lb.

The friction drop for the high pressure supply main will vary with the pressure used, but it may be said to average approximately 1 lb. per 100 ft. run, with the pressures in ordinary use.

At the closing professional session held on Thursday morning there was discussion and commendation of the good work reported in "Warm-Air Furnace Research" by Prof. A. C. Willard, and papers were presented on "Conservation of Coal by Saving Exhaust Steam," by William B. Hoyt; "Combustion," by Morgan B. Smith; and "Cracking Cast-Iron Sectional Hot Water Boilers," by C. R. Honiball, in which the author of the paper recited causes of deterioration and conditions that had come under his personal observation. In some cases it was noted that "thinning" of metal occurs at the bottom of sections in the firebox, leaving it no more than 1/16 in. thick.

National District Heating Association

NATIONAL District Heating Association held its tenth annual convention in the William Penn Hotel, Pittsburgh, June 10 to 13. About 150 members and guests participated in one of the best convention programs that have been carried out by the association. As stated elsewhere in this issue, the American Society of Heating and Ventilating Engineers simultaneously and at the same hotel held their summer meeting and several of the professional and social sessions of the organizations were joint sessions that brought about closer coöperation of the two societies. In addition to the joint banquet and boat trip up Monongahela River and visit of inspection to the McKeesport Works of the National Tube Co., an enjoyable trip was made by members and guests to the East Pittsburgh works of the Westinghouse Electric and Manufacturing Co.

J. C. Hobbs, Pittsburgh, Penn., was elected president for the ensuing year and D. L. Gaskell, Greenville, Ohio, was reëlected secretary-treasurer.

Report of Advancement Committee

There are on record a number of decisions in rate cases before state commissions where these bodies have established rates that show a good return on the investment. These decisions of commissions bring to our attention the necessity of doing all we can to help ourselves before asking for outside assistance in the form of increased rates.

Your committee has found plants earning a net return on what could be called a fair value, but the value allowed was complained of by the plant owners as being too low. It is a difficult thing to satisfy both sides of a rate case, and yet it is true that less real antagonism has been shown against heating-rate increases than any other utility business.

Most heating companies have been granted increases that have made it possible to weather the terrific conditions of the last few years. The high-cost period has brought out new problems or magnified what were considered minor problems. It has been the means of establishing a higher level of rates and has established the value of efficient operation. There will be a tendency to revert to lower rates, and probably the greatest problem before the companies is to keep the rates up to a point where a sufficient return is earned.

There has been a tendency to abandon some of the heating plants in the last two years. It is difficult to tell what the outcome will be. Many successful electric-plant operators will have nothing to do with a heating plant. Other equally good operators are earning a fair return on their heating systems. All the plants that have been abandoned were not economically sound. That is the real cause of stopping operation.

The change in electric production has made it difficult for the combination heating and lighting plant to exist. Large central stations with long transmission distances have put the smaller plant out of business. It is hard to find a steam plant exhausting into the atmosphere today. This will change conditions for the heating plant. It will require a straight heating plant with rates higher and investment lower. The high-pressure plant may fill this situation. It is a thing that must be studied.

The last two years of high fuel and labor costs have certainly jolted us into a desire to look about for all the possibilities of improvement we can find. In general it can be noted that the central heating industry needs higher rates and all the benefit it can get from the operation in combination with electric generating plants, or a design of a straight heating plant that will fulfill the conditions.

Report of the Station Operating Committee

On account of war conditions, it was out of the question to carry out any experimental work or tests. However, the committee endeavored to accumulate such data as might be procurable, and as would give the experience in successfully operated stations, and to report same. With this in mind, a list of topics was made up, and sent out with the request that such information as might be available on same be given. As a result the committee received valuable contributions from members on Proper Preparation of Fuel Before Its Delivery to the Fireman; Coal and Ash-handling Methods, Giving Advantages and Disadvantages of Different Systems; Station Organization with Reference to Obtaining Best Efficiency in the Burning of Fuel; The Bonus System; Causes and Remedies for Pitting and Corrosion in Boilers and Economizers: Experiences with Higher Steam Pressures.

Report of Public Policy Committee

The report of the Public Policy Committee covers subjects that have been most prominently brought out by conditions under which heating plants have been operated. It covers the following topics: (1) Rates and Their Relation to the Public; (2) The Relation of the Public and the Utility; (3) The Responsibilities of Labor; (4) The Trend Toward Socialism in Public Utility Operation.

The public is much more concerned in its service than in the rates paid for that service. When rates are mentioned, the public and the utility are too much like game chickens, always ready to fight, the one for a reduction in the price paid for the service, and the other for an increase in the return on its investment, which is usually inadequate. If this antagonistic attitude would bring relief to either of the parties, the fight might be worth while, but it does not. The public is not benefited by the saving in rate, and the utility cannot get any rate within the range or reason that would redeem it from the crushing burdens with which the public has from time to time loaded the utility. This, it is thought, is one of the most important phases of the subject that today faces the public and the utility.

The establishment of competent and quick acting tribunals, wholly divorced from local or political influence, is vitally essential to the life and usefulness to the public of the utility. Rates cannot be reduced from war-time fixing until war conditions are completely removed, and such condition is not in sight at this time. Public sentiment in the most favorable degree toward a utility should be encouraged, and needed changes in our laws regulating utilities should be such as to relieve them from many of the unjust burdens they now bear.

Major Charles N. Green, U. S. Engineers, reviewed the activities of the Construction Division of the Engineer Corps in the rapid preparation of camps and cantonments, the bulk of this work being accomplished under the direction of engineers recruited from civilian ranks.

Report of Accounting Committee

In the last report of the Advancement Committee it was recommended that a proper classification of accounts and a method for division of expenses of combined heating and electric utilities be worked out possibly in coöperation with the National Electric Light Association.

The Accounting Committee recommends that the Heating Association join with the committees from other public-utility associations, in working toward a uniform classification of accounts.

Standard Rules for Computing Required Radiation

It has been the desire of a great many members of the association for the last few years to have the National District Heating Association adopt a standard rule for figuring required steam and hot-water radiation. There have been several papers on this subject presented before the association, and as there was such a great number of rules used by the various member companies, some of which did not check within 50 to 75 per cent. of each other, the adoption of a standard rule has been carried over from year to year by the association with no action taken.

Two years ago when the Educational Committee decided to get up an association handbook, it was suggested that they adopt a standard rule for figuring radiation which would be known as the National District Heating Association rule and make it a part of the handbook.

The Education Committee was so busy that year with other matters that very little work was done on the radiation formula, and when the new committee on rules and regulations was appointed last year, the formulating of a standard rule for figuring radiation was turned over to them.

Numerous drafts of a proposed rule have been submitted to the committee in the last three months, and as there are fourteen members of the committee there has been a grat deal of criticism and discussion, which resulted in a great many changes and additions to the original draft. Some of the members were of the opinion that the scientific method was too complicated and that we should adopt a rule similar to rules known as Nos. 2 and 3. Other members were of the opinion that further additions should be made to the rule. As a result the rules which the committee submitted to the association for their approval and adoption do not meet with the individual ideas of each member, but the committee is agreed as a whole that if the proposed rules are adopted by the association as their standard, there is sufficient data, so that the various members of the association can compile simplified formulas to fit their local conditions.

The weight of discussion of the committee's report was to the effect that the proposed rules and methods of computing radiation were good when applied with engineering skill and due regard to conditions, and a motion was carried, recommending use of the rules for guidance, but not as the officially adopted standard of the association.

The Educational Committee's report made recommendations relative to compiling a loose-leaf handbook for use of men in the ranks as well as engineers and managers of heating untilites. The committee also made valuable recommendations on "Method of Turning in Steam in Large Lines," and a convenient method for determining the quality of steam furnished to the consumer.

N. A. S. E. Convention at Troy, N. Y.

The twenty-fourth annual convention of the New York State Association of the N. A. S. E. was held in Troy, N. Y., Friday and Saturday, June 13 and 14, with headquarters at the Hotel Rensselaer. The main floor of the hotel was tastefully arranged for the use of the supplymen, there being more than sixty firms represented.

The sessions of the delegates were held in the small banquet hall in the rear of the exhibit. While the attendance was not up to the standard, the meetings were interesting and the members enthusiastic and full of "pep." The visiting committee of the past year, formed by the retiring president, Patrick Cassidy, received a vote of thanks for its good work and will be continued during the coming year. There are five local associations that are not connected with the state organization, and a strong effort will be made to get these locals to join the main body. There is no reason why the New York State Association should not be the largest in point of membership, and there will be a big campaign for members during the coming year.

The opening exercises took place at the Hotel Rensselaer on Thursday evening. John J. Hanlon, chairman of the local committee, occupied the chair, and introduced the various speakers. Mayor Cornelius Burns welcomed the convention to Troy and said it was the boast of the citizens of the city that they were never outdone in hospitality. Patrick Cassidy, state president, responded. Francis M. Hugo, secretary of state, complimented the delegates upon the excellence of the preamble of the association. He said that there should always exist an identity of interests, a perfect harmony and a close coöperation between the boss and the fellow who handles the throttle. He told the delegates how proud they should be of their profession, as the victorious outcome of the war was largely due to the supremacy of the American engineer and machinist. Edward J. Lee, of Albany, an old and honored member of the N. A. S. E., fittingly responded for the engineers. Mr. Lee's remarks were received with enthusiasm. At this juncture the ceremonies closed and the company adjourned to the exhibit hall where State President Cassidy officially opened the exhibit.

There were several features of entertainment, including auto rides, shopping tours and a theater party. The principal entertainment was the banquet on Friday evening. The dinner was appetizing and well served. The music was good, and the entertainment furnished by Bob Jones, of the France Packing Co., Billy Murray, of Jenkins Bros., and Jack Armour, of *Power*, was well received. The guests of honor included Past President William J. Reynolds; National Vice President John J. Calahan; Edward J. Lee, and Robert J. Tobin, the last acting as toastmaster.

SOME OF THOSE WHO ATTENDED THE TROY CONVENTION

William J. Reynolds was the installing officer of the newly elected state officers, as follows: Patrick Cassidy past president, New York City; Robert Tobin, president, Troy; Arthur E. Dowd, vice president, Rochester; William Roberts, secretary, Yonkers; William Downes, treasurer, New York City; Edward Hoag, conductor, New York City; Charles Eider, doorkeeper, Niagara Falls; Edward J. Lee, chaplain, Albany; S. T. Thackerberry, state deputy, Brooklyn.

It was decided that the next convention would be held in Niagara Falls, the second week in June, 1920. Before the adjournment of the delegates the memorial services for the 47 members who passed away during the year were conducted by Captain J. Barrett Mugford, of the Salvation Army.

The Holyoke Power Situation

An interesting situation has developed recently at Holyoke, Mass., where the increasing load upon the municipal lighting plant and the limited opportunity for expansion have combined to raise the question of the future line of development of the city's power supply. The Turners Falls Power and Electric Co., operating one of the largest steam and hydro-electric transmission systems in New England, has offered to sell energy to the city in bulk for distribution by the municipal lighting department, and an extended report on the operating cost of the station, past and estimated, has been prepared for the department.

Considerable local opposition to the purchase of energy was voiced at a public hearing on the power situation held in Holyoke June 11, on the ground that a local plant could be built by the city to supply energy as cheaply and probably with greater reliability than an outside system. Advocates of buying the power, however, emphasized the superior economy of the large water power and steam equipment of the Turners Falls company, and pointed out that without the cheapest power available a modern industrial city cannot develop in competition with other communities. A wise conclusion was reached in a unanimous vote recommending the employment of an independent engineer to investigate and report upon the entire situation with advice to the city as to the best course to pursue, taking all possible factors into account. In the last analysis what modern industry wants is reliable power at the lowest feasible cost, and sentimental considerations have no place in deciding such a question as this, which affects the individual taxpayer as well as the commercial welfare of organized industry. Political considerations have no place in settling a large and important engineering matter such as that now before the citizens of Holyoke.

Engineering Council Notes

Contributed by M. O. LEIGHTON, Chairman
National Service Committee

The Committee on Classification and Compensation of Engineers of the Engineering Council have submitted a report of their activities in the Federal, the Railroad and the Municipal and State sections. This work has been mainly the preparation of classification schedules, the study of conditions affecting salary scales and the analysis of data collected. To facilitate this work in the Federal section a letter was sent to each departmental secretary outlining the work of the committee and requesting a list of engineering bureaus in his department and in issuing instructions to chiefs to furnish the needed data. Favorable responses were received from all departments excepting the War Department, which declined to furnish the information desired. A questionnaire was also prepared to be sent to the chief engineers of the railroads under Federal control on the supposition that the salaries of all the men in the various departments of the Railroad Administration were a matter of public knowledge.

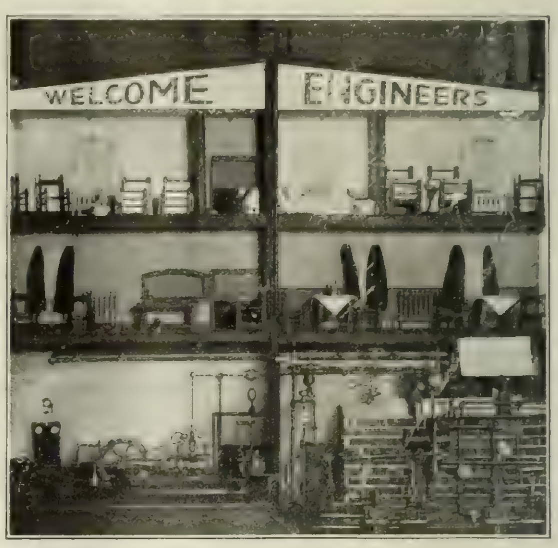
Before sending out this questionnaire Director General Hines was consulted and said that he did not think the matter should be approached in this manner. However, he stated that he could see no objections to our getting the information from members of the Founder Societies. The railroad section is confining its initial efforts to securing the required data from members of the Founder Societies. In the municipal and state sections the committee has found it necessary to undertake the formulation of a standard classification of positions and duties. The fitness of this schedule is now under consideration by the committee. As soon as an agreement shall have been reached, it is proposed to incorporate it into a questionnaire for circulation among the engineers of all states and the more important cities with a view to determining present compensation and changes which should be made.

In attempting to formulate standard rates of compensation for professional engineers, the first task is to find what rates are actually in force; the second task is to find what adjustment should be made to correspond to the great change in the cost of living. How great this change has been is realized by few. A record of average prices of the necessities of life, kept by R. G. Dun & Co., shows that prices have increased steadily for twenty-two years. On staple articles purchased July 1, 1897, for $72.45, the price had risen on Oct. 1, 1918, to $233.23. The unions have compelled an increase in wages for their members, and the unskilled laborer has been, especially during the war, practically able to set his own price on his services. No such increase has come the way of the salaried professional man. What increase has been granted is only too often wholly inadequate to make up for the increase in the cost of living. There is no doubt that if an unprejudiced investigation were made, it would show that the large proportion of salaried workers in professional occupations have been unable to pay their living expenses from their earnings for the last three years. Every indication is that the present condition of high prices will stay for several years yet. If this is the case, then the salaried worker is entitled to have his pay brought back in purchasing power to where it was fifteen years ago.

There is another aspect to the compensation of the professional worker which has frequently been misunderstood. The pay of professional engineers has for many years been based largely upon the idea that a young man in the earlier years of his work should expect a modest salary because of the future he might look forward to. Perhaps this idea was right when the demand for engineers was greater by far than the supply and the few properly trained men that were turned out by the engineering schools and engineering workshops rapidly worked themselves to positions of large responsibility, commanding high salaries. This is far from the conditions confronting the engineering graduate today. A very few can ever rise to high positions. The man who does is always a man of exceptional ability, and the man of exceptional ability alone is able to discount his early salary for the sake of his prospect. To hold out similar prospects for the average technical worker, which they have not one chance in twenty of ever attaining, is gross deception. The committee believes therefore that the dollar of salary must be considered with regard to what it will purchase today and is likely to purchase next year, and not with regard to the value of the dollar ten or fifteen years ago. This increase is not only necessary as a matter of justice to the engineer, but in order that engineering work may be maintained on the plane that it must be to secure economical and efficient work. There is no economy in paying such men at rates inadequate for their support. It merely tends to drive the abler men into other occupations and to leave in charge of the work only those of less ability, who are unable to make a change.

Iowa State Convention, N. A. S. E.

On June 11-13 the Iowa State Association of the National Association of Stationary Engineers held its sixteenth annual meeting at Marshalltown, Iowa. The "Victory" convention was one of the best in the history of the state association. The attendance was good, exhibitors had to be turned away for lack of space, there was a good selection of interesting papers, and the business sessions were of the short, snappy variety for which the Iowa Association is noted.



MODEL OF HOTEL POWER PLANT

On Wednesday afternoon the first executive session was called to order by Royal H. Holbrook, owing to the temporary absence of President Mullin. Mayor Wilson extended a hearty welcome to the engineers. In the response Fred Raven, national secretary, stated that efficiency was the motto of the association and pointed out that there is urgent need of better-educated engineers to lower the cost of production under the handicap of higher prices for everything entering into the generation of power. Herman Hiese, vice president, officially opened the convention, appointed a credential committee and conducted a motion for adjournment to visit the Iowa Soldiers' Home. "From Ore to Finished National Pipe" was the title of the first paper, and the second was, "The Flow Meter and Its Application in the Measurement of Steam, Water and Air," by J. B. Hoelz, of the General Electric Co. Outside of the records made available by the meter the big thing in its use, according to Mr. Hoelz, is the education of the fireman. By watching it he can see the immediate effects of everything he does. The meter assists in equalizing the load on the various boilers of a plant, guides the fireman in setting the draft or regulating the feed water, indicates a loss of effective grate area, leaky tubes, surface covered with scale or soot, or in fact anything that tends to reduce the output. The use of a steam meter on the supply to a turbine was also important as it would immediately show a rise in water rate, which for the same load would indicate there was something about the turbine requiring attention.

C. M. Brigham, of the C. A. Dunham Co., in an illustrated address pictured the evolution of heating, the troubles formerly prevalent with single-pipe and two-pipe systems and the present way of removing air and water of condensation by means of a Dunham radiator trap.

On Thursday morning there was a short business session, followed by a practical talk on pressure gages by G. F. Ruopp, of the Marshalltown Manufacturing Co. The speaker explained the action of the bourdon gage and showed different types of tube for light and heavy steam pressures and tubes for ammonia and hydraulic gages. During the afternoon a tour of inspection was made to the principal manufactories of the city, including the Fisher Governor Co., C. A. Dunham Co., Central Foundry Co., Daily Boys and Their "Pop," and Marshalltown Manufacturing Company.

Friday morning the principal order of business was the appointment of a committee of five, including the president and secretary, to act in conjunction with the Central States Exhibitors' Association and take full charge of the state convention financially, educationally and socially. It has been a number of years since the Iowa association has been in the exhibitors' circuit, and it is gratifying to see them back in the good old way.

Election of officers resulted as follows: President, Herman Hiese, of Des Moines; vice president, H. G. Hammond, of Davenport; secretary, P. P. Kramer, of Des Moines; treasurer, J. A. Coulson, of Sioux City; conductor, S. C. Dike, of Dubuque; doorkeeper, John Rockwood, of Clinton; state deputy, Royal H. Holbrook, of Cedar Rapids. Dubuque was the choice for the next convention city.

The morning sessions ended with an interesting lecture on the "Cost of Making a Kilowatt-Hour," by Arthur G. Huntington. The high light of the talk was that the engineer must make himself part and parcel of the balance sheet of the firm. The engineer is responsible for 10 to 20 per cent. of the cost of doing business, and he must impress upon the management the part he plays in connection with the balance sheet.

On Friday afternoon George F. Hessenbruch, of St. Louis, favored the convention with a lecture on isolated plants. He pointed out that the central station had many advantages over the isolated plant in producing current cheaply. They had many technical men who were experts in their particular line, had every kind of instrument to give all operating data necessary, a complete trained crew for the work and the privilege of consulting with the specialists previously mentioned. The isolated plant did not have the coöperation and coördination of the central station, and in addition it was usually handicapped by the management insisting on keeping down expenses, although this situation had been relieved somewhat by the education received in the past two years. As to relative costs the isolated plant no longer had the marked advantage of pre-war days. Whether the advantage rested with one or the other depended a great deal on balancing the steam and electrical services and the particular conditions existing in each case. No general deductions could be made that would cover all cases. The speaker reviewed his experience in 39 isolated plants that had been taken over by the central station to supply all services. Eleven of these stations have now resumed operations with their own plant owing to the high cost of the service, and it is probable that the balance of the 39 plants will follow suit before the end of the year.

Engineered by the Fisher Governor Co. and the C. A. Dunham Co., the banquet Friday evening was a great success. L. C. Abbott acted as toastmaster. Prof. W. H. Meeker, of Iowa State College, made the first address, his topic being the "Evaporative Performance of Steam Boilers." He reviewed the growth in the size of boilers and incidentally showed that it had not kept pace with the increase in present ratings. There were several ways by which engineers were now endeavoring to increase the operative performance of boilers and to reduce the space occupied. One way was to rearrange the heating surface so as to utilize more of the radiant energy from the fire. Increasing the velocity of the flow of gases and the flow of the water within the tubes were also factors influencing the economy and increasing the capacity of the boiler. Another factor being given consideration is the use of cones on the heating surface to break down the film of dead gas next to the plate. There are possibilities of increasing the heat flow from 65 to 75 times, as compared with the results now obtained with plain surfaces. Fred Raven, national secretary of the association, followed, briefly expounding the reasons for the existence of the N. A. S. E.

As a fitting close to a banquet of engineers, Royal H. Holbrook told in a most interesting way the story of James Watt, reviewing his early days and following up his later career as an inventor. On this subject Mr. Holbrook is an authority. He has made a most careful study of all available literature dealing with the early days of the steam engine, and it was the unanimous opinion that his discourse from the standpoint of interest was exceptional.

Among the exhibits at the convention a model hotel power plant consisting of boilers, engines, generators, steam pumps, heating system, feed-water heater, steam trap, regulating valves, and all complete, made in miniature size and operating at a pressure of 30-lb. gage, attracted a great deal of attention from the visitors. The miniature plant performed the services of standard-sized apparatus, supplying light and heat, and being equipped with the necessary gages, safety valve, etc., used in the average plant. It had been prepared by the Fisher Governor Co. and the C. A. Dunham Co.

American Order of Steam Engineers

The American Order of Steam Engineers held its thirty-third annual convention at Atlantic City, N. J., during the week beginning June 9, with headquarters at the Continental Hotel. The attractive location of the meeting this year brought out a full attendance.

The several sessions of the delegates were held in the Morris Guards Armory, a block from the hotel headquarters. The main drillroom of this building was tastefully decorated and arranged for the use of the supplymen in the display of power-plant equipment and engine-room accessories. The exhibit was liberally patronized, fifty-three firms occupying booth spaces.

Many important subjects were discussed at the sessions and measures conducive to the welfare and uplift of the engineers in general were passed upon. The treasurer's report showed that the organization is on a sound financial basis. On Tuesday evening, in the exhibit hall, the engineers gave a complimentary entertainment, which was greatly enjoyed by a large attendance. The entertainment on Thursday, under the auspices of the supplymen, proved a success in every particular.

At the final session of the delegates the following supreme officers were elected and installed: W. Scot Price, chief engineer; Philip S. Kirkwood, first engineer; Harry Dunn, recording engineer; William S. Metzler, corresponding engineer; William R. Smith, treasurer engineer; Dan Bunting, master mechanic; Harry Oler, junior master mechanic; William Kurtz, inside sentinel; William Arnold, outside sentinel; D. B. Heilman, trustee; and James Lightfoot, chaplain.

The American Supplymen's Association elected its officers for the ensuing year, as follows: Porter G. Jones, Dearborn Chemical Co., president; William Lindenfelser, Jr., Texas Co., vice president; Roy C. Downs, Engineering Supply Co., secretary; John W. Armour, *Power*, treasurer. An executive committee consisting of twelve members representing leading supply houses was elected.

At the conclusion of the memorial services on Friday, it was decided to hold the next convention in Baltimore, in June, 1920.

Progress in Adoption of A. S. M. E. Boiler Code

The American Uniform Boiler-Law Society in Bulletin No. 13, dated June 10, makes a report of the activities of the society in the different states since Mar. 10, 1919, the date of the last bulletin. The report of progress by states follows:

Delaware—The Legislature convened in January. The enabling act was introduced in the Senate by I. L. Long, and known as Senate Bill No. 144. H. B. Bradford and Mr. Cox of the Edge Moor Iron Co, rendered valuable service. At the request of Senator Long, we addressed the Senate and House in the interests of the A. S. M. E. Code and the bill, which was unanimously passed by both houses and signed by Governor Townsend on Apr. 8.

The bill provides for a board of boiler rules consisting of five members: One a professor of mechanical engineering; another a manufacturer of boilers; another a user of boilers; another a mechanical engineer; and the fifth a licensed stationary engineer. The bill carries an appropriation of $300 for the printing and distribution of the rules formulated by the board.

Rhode Island—The Legislature convened on Jan. 2. Our bill, known as Senate Bill No. 159, was introduced by George T. Gorton. The bill was in charge of Judge James Harris, of Providence, and had the active support of the leading manufacturers, engineers and others. It was passed unanimously by both houses and signed by Gov. R. Livingston Beekman on Apr. 23.

The bill carries the following provisions: The appointment of a chief inspector, salary $1800 per year; the appointment of one or more deputy inspectors, salary $1200 per year each, and all traveling and other necessary expenses incurred by him in the discharge of his duties. The chief inspector must formulate and adopt a standard code of rules for the construction, equipment, installation and inspection of boilers, which standard and rules shall be based upon the standard code of rules published and enunciated by the A. S. M. E., and the inspector shall amend such standard code of rules from time to time, basing such amendments on any amendment made by the A. S. M. E. in the standard code of rules published and enunciated by the society.

Exemptions: Boilers subject to Federal inspection and control, together with boilers carrying a pressure of 15 lb or less per square inch steam, or 30 lb. or less per square inch water; and boilers that are inspected and insured by companies chartered for the purpose of insuring steam boilers and authorized to do business within the state during the time that such insurance remains in force, provided due evidence of such inspection and insurance shall be furnished to such inspector, either by the company furnishing such insurance or by the person or persons insured. The act takes effect Sept. 1, 1919.

Missouri—The Legislature convened Jan. 8. The enabling act, known as Senate Bill No. 622, was introduced in the Senate by Conway Elder and in the House by Hugh K. Wagner. James A. McKeown, president of the John O'Brien Boiler Works Co., St. Louis, was in direct charge of the bill, assisted by Mr. Burton and Mr. Hester, of the Kewanee Boiler Co., together with C. D. Ashcroft and J. P. Morrison, of the Hartford Steam Boiler Inspection and Insurance Co.; D. W. Chipman, Jr., Maryland Casualty Co.; Edward W. Schadek, the St. Louis Boiler Manufacturers' Association, the Engineers' Club and the St. Louis Section of the A. S. M. E., as well as Senator Elder and Representative Wagner. The bill has passed both branches of the Legislature and is now in the hands of Governor Gardner for his signature.

The bill creates a board of boiler rules consisting of five members, four of whom shall be citizens of the state of recognized knowledge of the construction and use of steam boilers. The fifth member shall be the state factory inspector. The rules and regulations as formulated by the board of boiler rules shall conform as nearly as possible with the Code of the A. S. M. E. The rules shall become effective upon the approval of the governor, but rules applying to the construction of new boilers shall not become effective until Jan. 1, 1920. The sum of $1000 is appropriated for printing and distribution of the rules formulated by the board.

Michigan—The Legislature of 1917 passed a bill authorizing the appointment of a board of boiler rules to formulate rules and regulations for the construction of boilers. The rules and regulations so formulated were subject to the approval of the governor and attorney general. The following persons are members of the board: G. W. Bissell, chairman; E. C. Fisher, vice president; G. L. Christensen, secretary; R. I. Higgie; J. C. McCabe, chief inspector, Detroit. After a great deal of time and work on the part of the board and others, Michigan is now operating under the Code.

New York—Under Section 91 of the Labor Law, the New York State Industrial Commission in 1917 adopted the Code —to apply only to factory buildings. There was no provision made for the inspection of boilers in any class or type of buildings other than factories in which steam boilers were being operated above 15 lb. pressure per square inch. A bill was introduced by the Boiler Inspection Department, in both Senate and House, which authorizes the Inspection Department to make inspections of all boilers carrying a steam pressure above 15 lb. per sq.in. in all classes and types of buildings, and was known as House Bill No. 257. We gave this bill our unlimited support, appearing before the Senate and House Committee. The bill passed both houses, has been signed by Governor Smith, and is now known as Chapter 299, Laws of 1919. We understand the Industrial Commission will adopt the 1918 edition of the Code.

Washington, D. C.—The General Engineering Depot now specifies that all new boilers are to be built in accordance with the A. S. M. E.

Florida—The Legislature convened on Apr. 3 and our bill, known as Senate Bill No. 399, was introduced by Senator Carlton. We have the active support of the Florida Engineering Society, the attorney general and others. We were in direct touch with the situation, having visited Tallahassee with C. S. Hammatt, of the Florida Engineering Society, and appeared before the Senate committee, which reported the bill favorably. The bill has passed the Senate and is now in the House.

Alabama—The Legislature convened Jan. 10 for a fifty-day session. The Legislature convenes once in four years. Our bill has been introduced and is known as House Bill No. 330, and will be acted upon after July 8. W. P. Caine, chairman, Birmingham Section A. S. M. E., has been active in our behalf, assisted by manufacturers, the Alabama Branch No. 3 of the N. A. S. E. and others.

Georgia—The Legislature convenes on June 27, and our bill, which has been carefully drawn, meets with the approval of the governor, the commissioner of commerce and labor, the Georgia Manufacturers Association and the Atlanta Section of the A. S. M. E. We understand that the governor will recommend the legislation in his message to the Legislature, and we believe that Georgia will adopt the Code.

Increasing recognition of the value of the Code is indicated by its use in technical schools as a text or reference book. It is now used as a reference book at Stevens Institute of Technology, Sheffield Scientific School of Yale University and in the course in boiler design at the Rensselaer Polytechnic Institute. It is reported that the Code is also in use at the Virginia Polytechnic Institute, Georgia School of Technology, the University of Texas, the Tulane University of Louisiana and the University of Florida.

It is, moreover, used in the Republics of Argentine, Paraguay and New Zealand. Also the Government specifies boilers in use at the Canal Zone and according to Specification No. 2362 for power-plant equipment at the Naval Training Station, Newport, R. I., "boilers and accessories used by this department are to be constructed to the A. S. M. E. Boiler Code."

The following states and cities have adopted the A. S. M. E. Boiler Code: States—New York, New Jersey, Pennsylvania, Delaware, Michigan, California, Missouri, Rhode Island, Wisconsin, Minnesota, Ohio, Indiana. Allegheny County, Penn. Cities—Detroit, Mich.; Erie, Penn.; Kansas City, Mo.; St. Louis, Mo.; Philadelphia, Penn.; St. Joseph, Mo.; Chicago, Ill. (will accept).

Pulverized Fuel for the Railways

At the eleventh annual convention of the International Railway Fuel Association, held in Chicago the week of May 19, the committee on pulverized fuel, of which W. J. Bohan, of the Northern Pacific Railway, is chairman, presented an interesting report consisting of a summary of results obtained by the use of pulverized fuel in locomotives. To date five different American railroads—the Atchison, Topeka & Santa Fe; Chicago & North Western; Delaware & Hudson; Missouri, Kansas & Texas, and the New York Central—have successfully operated during test periods individual locomotives equipped for burning pulverized coal. These tests were all made under regular service conditions and demonstrated that locomotives burning pulverized coal will meet the train-handling conditions imposed by the different classes of service. None of the locomotives tested were in service at this time, it being necessary in most instances on account of war activity and the demand for power to remove the pulverized-fuel equipment and discontinue the experiments. Following are summaries of results obtained from three different sources:

A carefully conducted test between two engines of the same class, one burning pulverized coal and the other hand-fired, showed that a saving of 23 per cent. in fuel burned could be made by burning pulverized coal. The main difficulties encountered were the slagging over of the flue sheet and burning out of the brick arch. The slagging was largely overcome by an air jet to blow off the slag accumulations. A number of burner arrangements were tried, but it was found impossible to prevent the rapid burning out of the brick arch. The cost of replacing the arch brick largely overcame the saving in fuel, and the delay to the locomotive was a decided drawback. A comparison of total costs of hand-firing versus pulverized-coal firing on the locomotives tested, which include cost of pulverizing, cost of handling, cost of arch maintenance, interest and depreciation, showed the hand-firing to be most economical. In fairness to the pulverized coal it was thought possible to design a firebox that would avoid such troubles as burning out of the brick arch and show an advantage in favor of the pulverized coal.

COST OF PULVERIZING

A second report stated that pulverized fuel had been burned satisfactorily. All the steam needed had been generated, with splendid control all the time, when using 60 per cent. anthracite and 40 per cent. bituminous coal, the latter fuel being necessary to increase the volatile. Economy was quite another thing, and unless a poor or byproduct coal could be purchased at a price that would absorb carrying charges, operation, etc., of a pulverizing plant and not exceed the price of a satisfactory lump coal, the question would bear careful analysis. There is no saving in the quantity of fuel used when pulverized; in fact the difference is in favor of the lump coal. Pulverizing costs between 45 and 50 cents per ton.

By a third source the burning of pulverized fuel in a locomotive was considered easy and had proved satisfactory. The only difficulties were with the drying, pulverizing and handling of the coal, and also the danger in connection with it. In case of a large number of engines being equipped to burn pulverized coal, were the plant to be blown up, burned or otherwise made inoperative, the locomotives would be tied up until the plant was in service again.

Something like 200 pulverized-fuel installations on stationary plants were in operation throughout the country. These plants were reported as successfully burning all grades and classifications of anthracite, bituminous, subbituminous and lignite coals in the pulverized form.

The development of the art of burning pulverized coal during the past two years has shown marked progress in that the experimental work done and tests made, although still incomplete, have demonstrated the apparent soundness of the principle of burning coal in a finely divided form in suspension, and that the complete commercial success depends upon the further careful working out of such details as correct determinations of proper fineness of the various grades of coals and economical and efficient methods and apparatus for preparing, storing and transporting the pulverized coal to the stationary plant or to the locomotive furnace.

It has not been clearly established that coal ground to the extreme fineness and dried to the extent recommended by most of the supporters of pulverized coal best meets the conditions of the practical user operating under widely diversified conditions. The tendency of explosion and spontaneous combustion, which is always present in coal of this character, should be eliminated entirely if possible to do so. The tendency of reabsorption of moisture in containers and transmission piping in stationary plants and at coaling stations of railroads will always be a problem in climates having extreme variations of temperature and humidity. Experiments should be made to determine if thoroughly air-dried coal ground to the fineness of, say, coarse granulated sugar and burned in suspension in specially designed furnaces will not produce greater overall economies.

PULVERIZING COAL ON LOCOMOTIVE TENDER

Further, in so far as the use of this kind of fuel on locomotives is concerned, it seems advisable to give more careful consideration to the individuality of the flexible steam locomotive as it exists today. It is not without the realm of possibility that a pulverizing and stoking device might be arranged that would prepare any grade of coal on the tender and deliver it to the firebox in the pulverized form, thus eliminating all expense incident to preparing and transporting pulverized coal from a central plant, which things create a great deal of doubt about the success of pulverized fuel at the present time. The same thing would also apply to a stationary plant in a modified form.

Much ill-advised engineering work and experimenting has been done and some snap conclusions have been rendered without careful analysis of the problem and without doing the very essential laboratory work necessary to establish fundamental facts. Some hurriedly prepared and conducted tests with incomplete and inadequate facilities and equipment have been made, particularly on locomotives on busy railroads during periods of heavy traffic movement. Such tests are more or less void of results, not only from lack of preparation and facilities, but also because employees cannot give them proper attention. For these reasons also adverse opinions and doubt about pulverized fuel prevail in the minds of many.

It did not seem to the committee that the laboratories of the great universities were being used to sufficient extent. Many of these universities have thoroughly equipped laboratories, and could thoroughly work out all the technical questions and lay the foundation for reasonably operative devices before making field applications.

"HEAT BALANCES" AND "CASH BALANCES"

It is particularly noticeable in the reports of pulverized-fuel tests received by the committee that practically all dealt with fuel economy only and with a deluge of figures and "heat balances" conclusively proved fuel economy to everybody's satisfaction. Not enough has been said about "cash balances." In this respect conclusive evidence is lacking about pulverized coal, at least in so far as the committee has been able to develop after careful inquiry.

There is little or no question about the ultimate practicability, efficiency and economy of burning coal in a finely divided form, both in stationary plants and locomotives. To develop this fact to a practical conclusion requires thorough coöperation of manufacturer and user. In view of the immense supply of bituminous, lignite and other grades of coals of various characteristics peculiarly adapted to the pulverized method of burning, it is suggested that as soon as business conditions again adjust themselves the railroads, with the assistance of manufacturers and universities, make the necessary conclusive and exhaustive tests and develop the fixed principles of methods and apparatus necessary to successfully meet the urgent demands for vastly more economical burning of coal. This is not a question of self-interest of either manufacturer or particular industry. It is one of national interest and urgency.

A National Employment System

A bill which aims to establish a national employment system has been introduced into the Senate by Senator Kenyon. This system would be called the United States Employment Service and be a bureau of the Department of Labor. It is designed to serve both sexes and plans to coordinate the public employment offices in the different states to create a uniform standard of supply and demand of labor by assisting when necessary in the transportation of workers to meet labor shortages in different sections of the country. It provides for an appropriation of four million dollars to be distributed on a per capita basis, among the different states for the maintenances of these offices.

The National Research Council

A bill recently introduced by Senator Gronna provides for "aid in the promotion of engineering research, industrial progress and scientific investigations." The bill also aims to assist in the development of national resources and the distribution of useful and practical information pertaining to these questions among the people of the country. It would appoint a national board of engineering and industrial experts, this board to be called the National Research Council. Its duties are to be the organization and coördination of engineering and industrial research in each of the states. Although the members of this board will receive no compensation for their services, the bill provides that actual personal expenses will be paid by the Government.

Russian Water-Power Possibilities at Dnieper River Rapids

V. V. Tchikoff, consulting civil engineer, Berkeley, Calif., writing in the *Engineering News-Record*, estimates the total potential water power of European Russia alone to be 20,000,000 hp. or more. This is mostly concentrated in the border regions of Russia. The Caucasus has about 10,000,000 hp., and there is about 2,000,000 hp. in the north lake region. All the hydro-electric stations of European Russia have only about 250,000 hp., and most of these stations are small.

The rapids of the Dnieper River present one of the most interesting possibilities for early utilization. The problem of developing these rapids has been worked out by many Russian and foreign engineers. This project was divided into two phases. The phase first was based upon the 37-year midsummer minimum discharge of 11,000 sec.-ft., corresponding to a turbine capacity of 238,600 hp. nominal, with a maximum of 316,800 hp. during the flood months of spring. The minimum discharge for a 15-day period is 15,100 second-feet.

For the second phase of the project there would be utilized about 22,000 sec.-ft., corresponding to a turbine capacity of 350,000 hp. nominal and 465,000 hp. maximum, and a total of 588,600 hp. nominal. For this there would be necessary auxiliary steam plants of half the turbine capacity, working 90 days per year. The maximum turbine capacity was assumed as 1.33 times the nominal capacity. The construction cost of the dams, locks, etc., was estimated at about $25,000,000, and of the turbines, generators, etc., $16,500,000 for the first and $21,000,000 for the second phase, including the auxiliary steam plant, but not the transmission lines to Ekaterinoslav and Alexandrovsk which were counted at $4,400,000. The profits of a year's operation for the first phase are estimated at $1,480,000 and for the second phase $1,700,000.

Two Hundred Million Dollar French Contract to American Firm

The Vulcan Steel Products Co., 136 Liberty St., New York City, has just received a cost-plus contract, valued at $200,000,000, for rebuilding the Nancy district of France. The preliminary work of accumulating an organization and obtaining bids on machinery and equipment of all kinds will be started at once, so that the actual construction work may go forward the moment the peace treaty has been signed.

Associated with the Vulcan Steel Products Co. are MacArthur Brothers and the McClintic-Marshall Co., which will handle the construction work. French labor will be used, and it is understood that preference will be given to French manufacturers of machinery. However, a vast amount of American machinery of all descriptions will be purchased.

The German War Commissary states that Germany's coal production is decreasing in all districts, because the pay is no longer based on the work done but has a minimum of 16 to 18 marks ($3.81 to $4.28, at normal exchange) per day. The present coal production in the Ruhr district is 9000 to 10,000 tons per day, compared with 34,000 tons in peace times and 24,000 tons during the war. In upper Silesia the daily output has been reduced to 2000 carloads, compared with 14,000 in peace times and 11,000 during the war.

New Publications

INDUSTRIAL MAP OF NEW ENGLAND

The First National Bank of Boston, through its commercial service department, has published an interesting industrial map of New England, showing by symbols and cuts the leading industries located geographically in the respective cities and towns. A key to the symbols, included in the map, enables one to locate at a glance the various industries. There is also a carefully worked out table of the industrial towns arranged by states, and the leading industries in each city and town are shown, which should be of interest and value to merchants and manufacturers throughout the United States. To further the development of foreign trade and to enable the foreign buyer to become familiar with the products which New England manufactures, this map will be published in other languages for distribution in the foreign markets of the world.

Personals

M. L. Requa has resigned as general director of the oil division of the United States Fuel Administration to accept a position with one of the large oil concerns.

W. H. Goodrich has resigned as chief engineer of the Stamford (Conn.) Gas and Electric Co., to become New York district sales manager of the McClave-Brooks Co.

Ralph T. Stone, who has been sales engineer at the New York City office of the Sullivan Machinery Co. for several years, has been put in charge of the company's new branch office at Room 810, Park Building, Cleveland, Ohio.

Major George W. Semmes, vice president and chief engineer of Akerlund & Semmes, Inc., has returned from France after nearly two years of service at the front. He will confine his activities chiefly to the management of the gas-producer department.

George R. Richey has been appointed New England sales manager for the Sullivan Machinery Co., to succeed George E. Wolcott, deceased. Mr. Richey was long associated with the late Mr. Walcott as sales engineer for the company in New England and eastern Canada.

Prof. Charles J. Tilden, well-known civil engineer and for many years head of the department of civil engineering at Johns Hopkins University, has been placed in charge of the new department of engineering mechanics at Sheffield Scientific School of Yale University.

Foster Callahan, recently released from service in the United States army, is acting as representative in several Southeastern States for the Safety Insulated Wire and Cable Co. Mr. Callahan formerly covered this same territory in another connection and is well known and popular in the electrical industry.

Vernon T. Brauns, who has a large acquaintance with chief and valuation engineers of railroads of the United States, has just assumed the management of the American Blue Print Paper Co. Some time ago, Mr. Brauns won national recognition through promoting a process for reproducing tracings for presentation to the Interstate Commerce Commission.

Oscar F. Rabbe has taken over the management of the Toledo district of the L. S Shaw & Co., sales engineers for boiler-plant equipment. He is well acquainted with Ohio engineers and is going back into the sales field after a number of years' connection with the operating departments of the Toledo Railway and Light Co. and the LaSalle & Koch Co. His office will be at 301-302 Spitzer Building.

Engineering Affairs

The New England Water Works Association and the Boston Society of Civil Engineers will hold a joint field day and excursion at Pemberton, Mass., June 25.

The American Boiler Manufacturers' Association will hold its thirty-first annual convention at the Lafayette Hotel, Buffalo, N Y., June 23-24. An interesting program is being arranged.

Business Iems

The Chalmers Pump nd Manufacturing Co., of Lima, Ohio which is a reorganization of the Challers Manufacturing Co., has purchased te entire pumping machinery business of te Canton-Hughes **Pump Co., of Wooster, Oio.** The officers of the new company a: C S. Brown, president; Frank D. Shnate, vice president and sales manage Fred Biszantz, secretary and treasurer.

The Niagara Falls Poer Co. has made the following changes its personnel: Paul A. Schoellkopf, wh was one of the first vice presidents of e company, has been elected president tosucceed Stacy C. Richmond, deceased; Joh L. Harper, chief engineer of the HydrauliPower Co., which was amalgamated with e Falls Co. last year, has been made a v president; and Walter H. Schoellkopf haleen made a vice president to fill the vacac caused by the death of Charles D. Hice.

Griggs & Myers, conting engineers, New York City, announcheir recent affiliation with Charles A Fuller, heating engineer, of New York, a Osborn Monnett, heating engineer, of Cicago, as associates. Mr. Fuller is a weknown specialist in heating and ventilati and has many important installations to s credit, in industrial plants, office builigs and other structures. Mr. Monnett njoys a wide reputation as an authority n the field of combustion and power-pla economics, in which he has had an extene practice.

Metallo Gasket Co. has ently been incorporated at New Brunsvk, N. J. The officers of the company arZeno Schultes, president and treasurer; eorge Geipel, vice president; Stanley S. ipel, secretary. Zeno Schultes was manag of the Goetze Gasket and Packing Cofor about 14 years. George Geipel has en an erecting engineer for 35 years, spalizing in refrigerating and steam-pov plants, and Stanley S. Geipel has had years' experience in mechanical engineng. The company will concentrate for time on its metallic corrugated copperisket with asbestos cord inlaid in the oer grooves or corrugations.

Trade Catags

The Steam Motors Co., Sngfield, Mass., has issued an instructive -page bulletin (No. 5) on "The Steam lor." The design, construction, applican, and specifications of this type of mr are covered. The bulletin is nicely prid and is wel illustrated.

The Irving Iron Works ., Long Isnd City, N. Y., has issued a-page calog 2-A, entitled "Irving Subv," which contains a very complete cription with illustrations, of grating a grating flooring used for architecturaindustrial and marine purposes or wherhe advantages of a fireproof metallic long are sought. The booklet is nicely pnl.

The American DistrtSteam Co., of North Tonawanda, N. has just issued a special 80-page cat descriptive of its central station a nterior heating equipment Also an ieresting folder entitled "The Radiat as the Floor" describing the Adsco apr Heating System. They will gladly snd same to anyone interested.

The Underfeed Stok o. of America, Detroit, Mich., has jus isued a new edition of the Jones "AC" catalog This shows a large sectional reroduction of the stoker in operation, wit the fire shown in actual colors. Typical boler settings are shown under different yps of boilers, as well as typical installaton. of this type of stoker. A copy of the atalog may be had free upon request.

The Jeffrey Manufaturng Co., Columbus, Ohio, has issued ts 75-page catalog No. 258, on "Standard Apron Conveyors." This catalog is devoted to installations showing the conveyors in service in various industries, specifications, general dimensions and other data of interest to the purchaser. Pages 4 to 9 contain useful notes that will aid the purchaser in selecting a conveyor.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7 80@7 95
Stove	7 95@8 15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2 15@2.75	$2 75@3 25
Philadelphia, gross tons	4 27@4 95	5 95@5 50
New York, gross tons	4 62@5 29	5 29@5 85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7 90	Pea	4 90	6 65
Egg	5.95	7.80	Buckwheat	3 40	5,
Stove	6.20	8.05	Rice	2 75	4
Chestnut	6.30	8.15	Barley	2.25	

Bituminous

	Spot	
		50
South Forks	$2.90 @ $3.25	$2 3 25
Cambria County		@ 2.95
(good grades)	2 75 @ 2 95	5 @ 2 95
Clearfield County	2 50 @ 2 75	95 @ 3.10
Reynoldsville	2 50 @ 2 7	
Quemahoning	2 65 @ 2	2 95 @ 3 10
Somerset County (best grades)	2 50 @	2.50 @ 2 75
Somerset County	50	2.50 @ 2 75
(poorer grades)	2 00 2.25	2 35 @ 2 50
Western Maryland	2 2 2.25	2 25 @ 2.40
Fairmont	2. 2.35	2.35 @ 2 60
Latrobe	2@ 2 75	2.60 @ 2 75
Greensburg		
Westmoreland	35 @ 2 60	2 35 @ 2 65
Westmoreland run-of-mine		

pper ports for both bituminous Quotations at 5c. higher on account of the and anthracit rates, and are exclusive of the difference in x. 3% war freig

PHILADPHIA—The price per gross ton f o b. cars at s for line shipment and f.o.b Port r tide are as follows:

Richmo	Line	Tide		Line	Tide
	$5 95	$7 80	Buckwheat	$3 40	$4 45
Brok	6 05	7 90	Rice	2.75	3 65
Eg	6 30	8 15	Boiler	2.50	3 50
S	6 40	8 25	Barley	2 25	3.15
a	5 00	6 60	Culm	1 25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2 55@$2 75	$3 25
Mine-run	2 35@2 50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2 45	$2 75	$2 40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
		5.25	.....
Blacksmith	...		

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
	3.95@$4.60
Black Creek and Cahaba	3 50
Corona	3.50
Jagger	5.00
Montvallo	

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

		Mt. Olive and Staunton	Standard
Franklin County			
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2 75	....	....
Williamson County			
Prepared sizes, lump, egg, nut	$2 55	$2 55	$2 00@2 25
Mine-run	2.35	2 20	1.60@1.75
Screenings	2 20	2.05	1.15@1.30
3-in. lump	....	2 30	
2-in. lump		....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; other rates 92½c

New Constructio

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PROPOSED WO

ectric n addi-

N. Y., Binghamton—Th Mgr. Motor Truck Co., 23 Wa ern N. Y. install steam heating Watertown, power in connection wi construction tion to its plant. E. power, canal,

N. Y., Black Riv tailrace. The Utilities Co., 58 2 vertical turbine will soon receive urtenances. J. B. of a power hous s, Ch. Engr. Noted including dam, company will generator u e N. Y. Telephone Co., Taylor, Pres York City, will install a March 11. ant in the 2 story, 100 x

N. Y., e exchange which it plans 15 Dey ratman Ave., west of Row- steam tal estimated cost, $200,000. 145 oorhies & Gmelin. 1123 Broad- to York City, Engr.

lan M **Brooklyn**—The Board of Educa- 00 Park Ave., New York City, will a steam heating plant in the school h it plans to build on Stillwell Ave. al estimated cost, $150,000. C. B. J. nyder, Municipal Bldg., New York City, Engr.

N. Y., Brooklyn—J. Manheimer, 1649 49th St., will install a steam heating plant in the 3 story, 203 x 302 ft. theatre which he plans to build on Flatbush Ave. and Albemarle Rd. Total estimated cost, $450,000. Carlson & Wiseman, 226 Henry St., Arch.

N. Y., Gouverneur—The Board of Education plans to appropriate $25,000 for installing a new heating and ventilating system and new system of sewerage, etc., at the high school on Main and Grove St. Address J. C. Dolan, Pres. of the Bd. of Educ.

N. Y., New York—The Chemung Iron & Steel Co., 39 Cortlandt St., is in the market for one 350 hp., two 100 hp. and three 50 hp. boilers; also 5 horizontal return tubular boilers, to cost about $2100 each. E. Quirk, Engr.

N. Y., New York—J. Eichler Brewing Co., 3582 3rd Ave., will soon award the contract for converting its 3 story, 62 x 84 ft. brewery at 169th St. near 3rd Ave., into an ice plant. Estimated cost, $37,000. A G. Koenig, 405 Lexington Ave., Engr. Noted June 10.

N. Y., Utica—The Utica Suspender Co. is in the market for small motors to drive webbing looms. G. A. Armstrong, Pres. H. G. Sturges, Cox Bldg., Utica.

Penn., Philadelphia—The McCray & Hunter Co., 3525 Germantown Ave., will soon award the contract for the construction of a 2 story, 13 x 72 ft. cold storage plant on Venango near Warnock St.

Penn., Philadelphia—The United Gear Co., 833 North Leighton St., is in the market for one 11-in. Gleason bevel gear generator.

Penn., Pittsburg—The Wappat Gear Works, 7123 Hamilton Ave., is in the market for one 6-in. Gleason bevel gear generator; one 16-in. Gleason bevel gear generator and one 24-in. Gleason forming bevel gear plane.

S. C., Columbia—The city will install a refrigerating plant and slaughterhouse, in connection with the abattoir which it plans to build on Broad River Road. Total estimated cost, $40,000. J. C. Johnson, Palmette Bldg., Arch.

Ky., Springfield—The Springfield Water & Electric Co. is having plans prepared by H. W. Mayfield, Engr., 298 West Oak St., Ludlow, for changing over their present D. C. light and power plant to an A. C. system; plans include a new 4 panel switchboard, alternators and engines, etc.

Ohio, Dayton—The Brownell Co., North Findlay St., is in the market for an electric traveling crane, 20 ft. bridge span, equipped with 3 motors, 220 v., a.c., 60 cycle, 3 phase.

Mich., Cedar Bank (Forsyth P. O.)—The State Board of Control, Capitol, Lansing, will install a separate power plant to contain 2 boilers, in connection with the administration building, etc., which it plans to build Total estimated cost, $500,000. B. Wickham, Sec'y. E. A. Bowd, 127 Allegan St., W., Lansing, Arch.

Mich., Detroit—The General Motors [illegible] Campbell Bldg., will install [illegible] steam heating equipment and [illegible] pumps in the 6 story, 150 x 150 [illegible] building which it plans [illegible] on York and Cass Ave. A. Kahn, [illegible] Bldg., Arch.

[illegible] Port Huron—C. H. Wills and J. [illegible] Bldg., Detroit, have purchased [illegible] land on the St. Clair River, [illegible], and plan to build a large [illegible]

Ill., [illegible] manufacturing plant. Plans include [illegible] construction of a separate power [illegible] the [illegible] building.

[illegible] the Melville Clark Piano [illegible] F. Wilson [illegible] St., has awarded [illegible] construction of a factory [illegible] 18th Place, to R.

Wis., Milwauk—West Randolph St. Co. 217 [illegible] installed in same. heating system [illegible],000. 6 story 60 x 180 [illegible] Fisher Furniture to build. Total estim[illegible] install a steam H. M. Euemann, 521 [illegible] power in the

Minn., Austin—The city [illegible] it plans in July for installing a [illegible] $250,000. plant at the municipal elec. Arch. [illegible] Pillsbury, 801 Metropolit[illegible] ive bids Minneapolis, Engr. [illegible]

Minn., Minneapolis—The state [illegible] build new generating units for the [illegible] light plant, to include fire alarm [illegible] etc. Estimated cost, $7[illegible],000. C. L. Pillsbury Co., 801 Metropolitan Life B[illegible] Engr.

Minn., Walker—The city will receive bids in July for 3 mechanical stokers to be installed at the State Sanitorium. Estimated cost, $[illegible],000. C. L. Pillsbury Co., 801 Metropolitan Life Bldg., Minneapolis, Engr.

Minn., Wells—The city plans to build a power plant and install boiler and stoking equipment. Estimated cost, $75,000. C. L. Pillsbury Co., 801 Metropolitan Life Bldg., Minneapolis, Engr.

Kan., Hiawatha—The city is having plans prepared for improving the waterworks system. Plans include the installation of pumps at the spring on County Farm, etc. Estimated cost, $25,000. Black & Veatch, Interstate Bldg., Kansas City, Mo., Engrs.

Kan., Sharon Springs—The city plans election soon to vote on $50,000 bonds for the construction of a power house; installing one 150 and one 100 h.p. engines; and improving the distributing system.

Kan., Topeka—The state will install a complete heating plant in the state house which it plans to build on 9th and Jackson St. Estimated cost, $50,000. R. S. Gamble, Arch.

Mo., St. Joseph—The city voted $500,000 bonds for improving the electric lighting plant. E. M. Stephens, Kansas City, Engr. Noted March 11.

Okla., Tahlequah—The city voted $200,000 bonds for the construction of a light and power plant.

Okla., Tulsa—The city plans to build a waterworks system, water to be taken from the Spavinaw Creek. Total estimated cost, $[illegible]. Project includes dam and power house, to cost $[illegible], land and clearing, $150,000, conduit, $2,500,[illegible], right of way, $[illegible],000, three reservoirs of 20,000,000 gal. capacity, $225,000, and 1 reservoir near the city limits to have a capacity of [illegible],000,000 gals., $311,000, power plant, $[illegible],000, pumping plant, $150,000, transmission lines, $[illegible],000, engineering, $250,[illegible]. H. A. [illegible], City Hall, Engr.

Okla., Tulsa—The Hinderliter Tool Co., 2 3 4 Madison St., will install a 20 hp. engine in connection with 1 story 18 x 125 ft. factory which it plans to build on Madison St. Estimated cost, $6,000. Engineer not selected.

Ariz., Duncan—The Ash Peak Mines Co. plans to build a power plant. A. Murphy, Jr., Supt.

Ariz., Mesa—The city plans election soon to vote on $60,000 bonds for extensions to the gas plant, installing additional electrical equipment and improvements to the water system.

Wash., Oroville—The Okanogan Power Co., 521 1st Ave., Spokane, which now has an investment of $[illegible],000 in the Okanogan mining country, has had plans prepared for the construction of a 60 x 350 ft. dam and the machinery for the first unit of a large power plant at a point on the Similkameen River, three and a half miles above Oroville; 2000 hp. will be available from the new plant with the completion of the first unit and the generation of 3000 additional hp. is anticipated from the second unit, which will probably be available early next [illegible]. Estimated cost, $150,000. E. Enloe, [illegible]kane, Mgr.

[illegible], Klamath Falls—The Klamath Heating [illegible] plans to build a central heating [illegible]. Estimated cost, $40,000. Funds [illegible] supplied by local capitalists.

Cal., Los [illegible] The Rubio Canyon Land [illegible] plans to build a pumping [illegible] Sacramento St. and lay a pipe line [illegible] reservoir. Estimated cost, $10,000.

Cal., Los [illegible]—The Board of Public Service Com[illegible], 645 South Olive St., voted $13,500,[illegible] bonds, $2,500,000 to be used for the [illegible] of power plant No. 2 in the San [illegible] canyon and power development [illegible] the Owens River gorge, and $11,000,[illegible] purchasing the distribution system [illegible] Angeles owned by the Southern Califo[illegible] Edison Co. E. F. Scattergood, 645 Sou[illegible] Olive St., Engr. Noted June 3.

Que., Verdun—The city p[illegible] to improve the electric lighting plant [illegible] is in the market for one 1000 kw. [illegible] turbine generator and boilers. Estim[illegible] cost, $125,000. G. E. Ghysene, City [illegible] Engr.

Ont., Boston Creek—The North[illegible] Ontario Light & Power Co., Timmins, p[illegible] to build an electric power station and [illegible] in the market for equipment for same.

Ont., Niagara Falls—The City Coun[illegible] plans to extend the hydro-electric system. Estimated cost, $18,000.

Ont., Guelph—The Northern Rubber Co., Ltd., will soon receive bids for the construction of a 1 story, 35 x 45 ft. power house, to be equipped with two 125 hp. boilers, a water heater and a 6 x 6 x 8 ft. vacuum steam pump to handle 1[illegible],000 [illegible] radiation. Plans include the installation of a vacuum steam heating plant. Estimated cost, [illegible],000. James, Loudon & Hertzberg, 36 Toronto St., Toronto, Engrs.

Ont., Lakefiel—G. K. Fraser plans to build an electric lighting plant and is in the market for equipment for same.

Ont., Parry Sound—The Town Council will receive bids for the construction of a power dam, intake, conduit, generating station and tailrace, etc. C. H. Mitchell, 1003 Bank of Hamilton Bldg., Toronto, Engr.

Ont., Scarbor—The city plans to build a pumphouse, water mains, etc. Estimated cost, $150,000. James, Loudon & Hertzberg, 36 Toronto St., Toronto, Engrs.

Ont., Scarbor—The Gendron Manufacturing Co., Ltd., 137 Duchess St., Toronto, plans to build boiler house and install a vacuum steamheating system in connection with the plant which it plans to build. Total estimated cost, $500,000. James, Loudon & Herberg, 36 Toronto St., Toronto, Engrs.

CONTRACTS AWARDED

N. Y., Alban—E. L. Walsh, Supt. of Public Wks., has awarded the contract for furnishing, testing and delivering battery charging motor generator sets with switchboard panels for the barge canal terminals in New York City, Contract 117, to the Electric Products Co., 1067 East 152nd St., Cleveland, $5,293.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing motor generator sets and switchboard at the Submarine Base, here, to the General Electric Co., River Road, Schenectady, N. Y. Estimated cost, $44,050. Noted Ju[illegible] 3.

Miss., Hollandale—The Commissioners of Black Bay[illegible] D. D., Greenville, has awarded the contract for the construction of a 1 story pumping plant, sluiceways, etc., here, to the De[illegible] Cement Tile Co., Greenville. Estimated cost, $24,600. Noted April 22.

Mich., Highland Park (Detroit P. O.)—The city has awarded the contract for the construction of [illegible] 4 story hospital and 2 story power house and laundry, etc., to the O. Rosenthal Construction Co., 603 Railway Exchange, Chicago, Ill. Estimated cost, $241,600.

Wis., Milwaukee—The Wisconsin Dye Works, 614 Mi[illegible]ell St., has awarded the contract for the construction of a 1 story, 18 x 40 ft. boilerhouse, to H. Breest, 1152 9th St.; contract for installing boiler in same has been awarded to Schwab-Lezotte, 16th and Canal.

Kan., Rosedale—The Kaull Mills Co. has awarded the contract for the construction of a mill, warehouse and a 1 story, 22 x 36 ft. boiler house, to the Eberhardt Construction Co., S[illegible]a. Estimated cost, $100,000.

Neb., York—[illegible] Lutheran Hospital has awarded the contract for the construction of [illegible] 2 story hospital and boiler house to A. [illegible] Olson, 5[illegible] Reliance Bldg., Kansas City, Mo. Estimated cost, $75,000.

Business Opportunities
Equipment Bargains
Wants
Jobs
Men

Men
Jobs
Wants

Business Opportunities
Equipment Bargains
Wants
Jobs
Men

Equipment Bargains
Business Opportunities

all the worth-while "Opportunities" of the power plant field. You will find them in the

SEARCHLIGHT SECTION

SEE PAGES 51 TO 64.

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P7
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Engin.

Power

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